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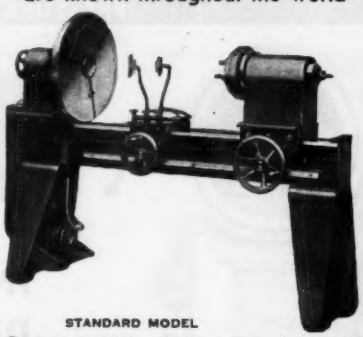

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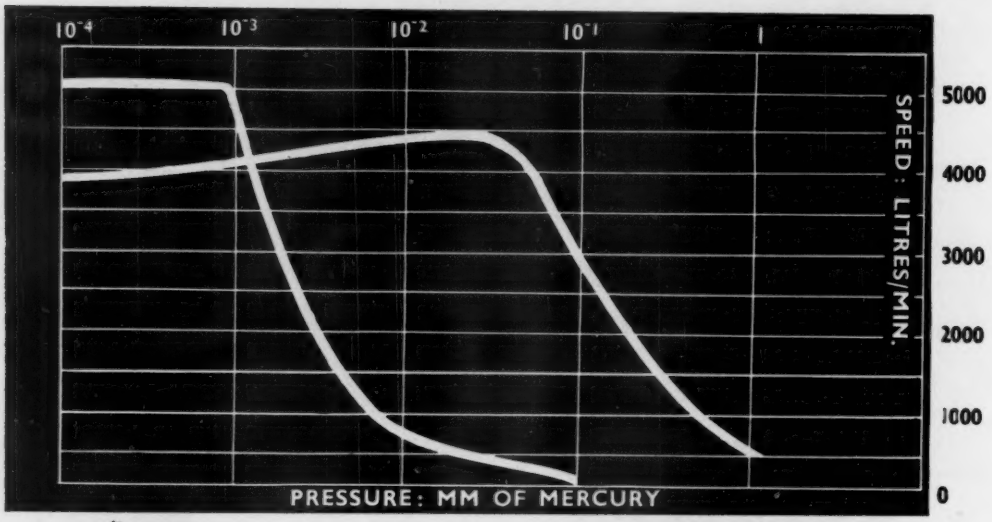

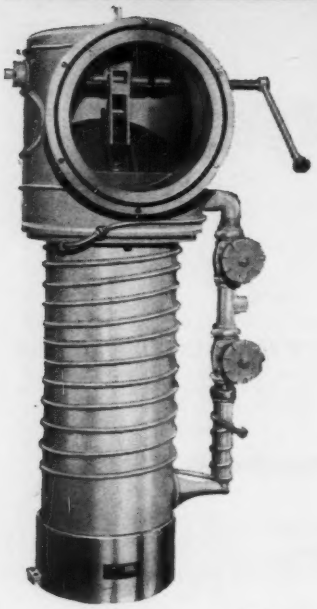

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CONTENTS

	Page
Technical Change and Industrial Relations	331
Early American Scientists. By Dr. A. R. Hall	333
The Earth as a Planet. By Prof. Arthur Holmes, F.R.S.	334
An Introduction to Animal Navigation. By Dr. Eric Duffey	335
The World of Plankton. By Dr. Sheina M. Marshall	336
Marriage in Primitive Society. By E. R. Leach	336
The Chesser Report. By T. H. Hawkins	337
The Ionosphere. By J. A. Ratcliffe, O.B.E., F.R.S.	339
A Gregarious Factor in the Natural Conditioned Salivary Reflexes of Sheep. By D. A. Denton	341
Obituaries :	
Vice-Admiral John Dodd Nares. By Sir John Edgell, K.B.E., C.B.E., F.R.S.	344
Mrs. Watson Davis	345
News and Views	345
The South Australian Museum. By Dr. F. S. Wallis	350
Use of Visual Aids in teaching Skilled Manipulative Tasks. By Prof. M. D. Vernon	351
The British Flora during 1956. By J. E. Lousley	351
Radio Wave Propagation	354
Physiology of the Pre-weaning Period. By S. A. Barnett	356
Fatigue in Metals. By Prof. F. C. Thompson	356
Astronomy at the Cape of Good Hope	357
Ice-forming Nuclei. By Dr. B. J. Mason and J. Hallett	357
1-Aminocyclopropane-1-carboxylic Acid : a New Amino-acid in Perry Pears and Cider Apples. By L. F. Burroughs	360
Hepatotoxic Action of Pyrrolizidine (*Senecio*) Alkaloids in Relation to their Structure. By Dr. R. Schoental	361
Hydrolysis of Adenosine Triphosphate by Mitochondrial Preparations. By D. K. Myers and Prof. E. C. Slater	363

Letters to the Editors :

Decomposition of Barium Azide.—B. E. Bartlett, Dr. F. C. Tompkins, F.R.S., and D. A. Young	365
Fulvic Acid : its Structure and Relationship to Citromycetin and Fusarubin.—F. M. Dean, R. A. Eade, R. A. Moubasher and Prof. A. Robertson, F.R.S.	366
Asymmetric Dialysis of Racemates.—Dr. V. O. G. Klingmüller and G. Gedenk	367
High-Intensity Flash Irradiation of Polymers.—J. L. Lundberg and L. S. Nelson	367
Ground-State Transitions in the Reaction $^{10}B(n,t)^{9}Be$.—Prof. E. W. Titterton, C.M.G., and T. A. Brinkley	368
A Connexion between the Granulation and the Structure of the Low Chromosphere.—Prof. Leo Goldberg, Dr. Orren C. Mohler and Jacqueline D. Brown	369
Intensity of the Radio Line of Galactic Deuterium.—R. L. Adgie and Dr. J. S. Hey	370
Relation of 11-Metre Solar System Phenomena to Solar Disturbances.—Prof. John D. Kraus	371
Measurement of Ionospheric Path-Phase for Oblique Incidence.—R. Price and P. E. Green, jun.	372
Ultra-Violet Band Systems of HF^{+} and DF^{+}.—J. W. C. Johns and Dr. R. F. Barrow	374
Comparison of Threshold of Hearing for Bands of Noise and for Pure Tones.—J. Wentworth-Jessop and Dr. P. Vigoureux	374
Role of Formate in the Biosynthesis of Chlorophyll *a*.—Morris Green, Dr. Kurt I. Altman, Jonas E. Richmond and Kurt Salomon	375
Nature and Site of Origin of the Hyperglycæmic Substance released following an Injection of Growth Hormone.—Anna Sirek	376
Metabolism of *dl*-Ornithine-2-^{14}C in Normal and Potassium-deficient Barley.—R. G. Coleman and M. P. Hegarty	376
Self-Alkylation of some Dialkyl Phosphate Esters.—Dr. D. F. Heath	377
Column Chromatography of Anthocyanins.—T. Endo	378
Dialysis of Small Specimens in Batches.—Dr. E. Ben-Gershom	379
L Forms of Bacteria and their Role in the Origin of Penicillin Resistance.—Dr. M. V. Nermut	379
Spore Formation in *Pellia epiphylla*.—Dr. A. J. Willis	380
Sickle Cell Gene in Indonesia.—Lie-Injo Luan Eng	381
Learning and Daily Activity in a Sandhopper.—D. W. Featherston and R. J. Macintyre	381
Salmonella vejle and *S. saint paul*.—L. Schrire and V. Bokkenheuser	382

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TECHNICAL CHANGE AND INDUSTRIAL RELATIONS

THE smooth introduction and assimilation of technical change is of increasing importance not only in Great Britain but also in many other countries. Upon it depends the extent to which Britain, for example, is able to reap the full benefit which the development of nuclear power can offer industry, and the advantages which advances in automation in various fields or the modernization of the transport system, particularly of the railways, make possible. This was fully recognized in the report on automation which was prepared and published last year by the Department of Scientific and Industrial Research. The report does not suggest that social resistance is likely to impede progress with automation: rather, the shortage of trained managers, engineers and technicians is regarded as likely to be the decisive factor determining the rate of progress.

None the less, the imperfections of present knowledge of the economic and social aspects of automation, compared with our knowledge of the technical possibilities, is strongly emphasized in the report; and with the emphasis on the importance of education at all levels and the hint that a major re-appraisal of university and vocational training in Britain may be necessary, some concrete suggestions are made for further research on the social and economic aspects of technical change. The economic and social research programmes sponsored by the Department of Scientific and Industrial Research, in fact, already include some general research into technical innovation, which, while not dealing specifically with automation, is designed to increase our knowledge of the factors governing the rate of technical innovation. One such study, of the relations between technical change and the social structure of large steel-works, was undertaken by the Department of Social Science of the University of Liverpool with the aid of grants both from the Department of Scientific and Industrial Research and the European Productivity Agency of the Organization for European Economic Co-operation.

The results of this study, by a team under the leadership of Dr. W. H. Scott, with Mr. J. A. Banks, Dr. A. H. Halsey and Mr. T. Lupton as senior members, have now been published under the title "Technical Change and Industrial Relations"*. Its aim was to clarify the factors which influence attitudes to technical change in industry by exploring systematically the relations between technical organization and social structure. It was hoped to throw light on the factors which promote or impede technical change by assessing how a particular structure influences attitudes to a possible or impending change, and, once a major change has been effected, by ascertaining the consequent changes in structure and whether those in turn had modified attitudes to change. For this purpose the more important aspects of the social system of the plant and its associated trade unions as a whole were studied with particular reference to the influence of technical organization and change on social structure.

The outcome of this study is presented with the lucidity and restraint that mark Dr. Scott's other books, and like those earlier studies it is concerned not only to promote fundamental knowledge but also to make a practical contribution to the solution of current practical problems. Quite apart from the topicality of its general conclusions, much of it is of particular interest to the industrial scientist and to the manager, as well as to all concerned with technical education and especially with training for management. The book also throws light on the problem of authority in industry which Sir Frederic Hooper discussed last year, and the qualities which are demanded of management at its various levels.

Reviewing the historical background and the present organization of the firm and the major phases of development, as distinct from the minor technical innovations which in a modern industrial enterprise can be an almost daily occurrence, the study brings out the way in which the increase in scale and differentiation has posed two main problems: that of increasing the number of workers and that of finding, or training, people with new types of skill. Generally, the former problem has been solved by the growth of a local community and extension of the area of recruitment; but there was some evidence that tradition influenced the adaptation of recruitment policy to changing occupational needs. Technical change and expansion, however, tend to reduce the relative effect of kinship in both recruitment and integration, and to enhance the importance of formal qualifications.

Next, the impact of technical change on management is described. Here the study shows how the necessity of appointing more managers with technical qualifications, many of whom have had to be recruited from outside, has made the occupational structure of the management less homogeneous, and its informal structure is probably now more complex and differentiated. The point of most general interest which is brought out in this chapter is the increase in the proportion of both junior and senior managers with technical and professional qualifications which has resulted from the technical changes examined. No great amount of attention appears to have been given by this particular firm to the problem of ensuring a supply of trained managers, and while there has been an increase in the recruitment of graduates, ideally a combination of experience and specialized knowledge was desired.

The recruitment of graduates to a firm which has previously employed very few involves some diffi-

* Technical Change and Industrial Relations: a Study of the Relations between Technical Change and the Social Structure of a Large Steel Works. By W. H. Scott, J. A. Banks, A. H. Halsey and T. Lupton. (Social Research Series.) Pp. x+332. (Liverpool: Liverpool University Press, 1956.) 17s. 6d. net.

culties, and clearly much more attention must be given to the training of such recruits—and indeed of all recruits—as industry now increasingly recognizes. Closer co-operation with the universities and with the technical colleges might well prove of great value here, and the study emphasizes in particular the value of a long-term policy and scheme for management recruitment and training, which in this firm has been handled on a rather *ad hoc* basis. This is perhaps more a consequence of the growing complexity of management problems to-day than a direct result of technical change. Technical change, however, has also tended to break up into separate compartments the informal structure of management, and certain cleavages between sub-groups, based on differences of function or personal background, were observed which could retard the assimilation and full exploitation of technical changes if effective integration of the structure was not maintained.

This appears to point to the value of the professional study of administration and of such courses as those which the Administrative Staff College can offer. The importance of education is again brought out in the analysis of the trade unions and of management–union relations. In the first place, this indicated the importance of the formal structure and the traditional values from which that structure is largely derived, and which are shared by management and the unions in the industry. In general, the formal structure and its traditional supports have proved adequate to limit potential conflicts arising from changes in the plant, so far as the process workers' unions are concerned. A major change, involving the re-allocation of many employees to radically different jobs, sometimes with loss of earnings and status, was accomplished without any breakdown of management–union relations.

With the craftsmen, however, difficulties arose in the absence of an effective formal structure. In the view of the craftsmen, an important change in occupational structure, involving a considerable increase in the size and power of the craft group, was not accompanied by an appropriate adjustment in their rewards. There appears to have been the same history of stable and mutually satisfactory relations, characterized by a wide measure of agreement and a willingness to compromise; nor was the right of management to make technical changes challenged. Indeed, the craftsmen appear to have an even more positive attitude to technical change and achievement than the process workers. There is no evidence that the changes were made any less tactfully, or that any less care was observed in consulting the unions. The difference brings out the dependence of union policies and attitudes and of management–union relations upon the attitudes of the employees who constitute the membership of the unions.

Those attitudes clearly will be influenced by the past relations between the unions and management, and by the extent to which integration of the internal shop-steward system into the formal structure has been secured. While, however, the craftsmen are probably in less danger of redundancy, which the study showed to be the most outstanding consequence of technical change liable to cause resistance to change in the minds of employees, they believe that their conditions of employment are less favourable than those of process workers, and not in keeping with the increased importance attached to maintenance work with the advent of more complex machinery under technical change and development. There is, as the study points out, a certain contradiction in the wishes of the craftsmen. Their desire to preserve their traditional craft allegiance and status is not entirely consistent with the closer association with the industry, its practices and norms which marks the process workers. None the less, unless the craftsmen's grievances are solved and external and internal negotiating procedure is satisfactorily integrated, technical change may be impeded, since its success is likely to depend increasingly upon the co-operation and efficiency of the craftsmen.

While, however, the study in general reveals little evidence of the existence of resistance to technical change which cannot be overcome by wise policy and good management, at least at this point it indicates that there are some practices in the unions which will require reconsideration and modification if progress is not to be impeded. The whole responsibility does not lie with management and, without enlarging on them, the study shows that restrictive and obsolete practices persist which are inconsistent with the conditions of to-day and which it is the responsibility of the unions to modify.

The report points to some particular problems which require further attention by the firm in question; but its interest is far from being limited to the demonstration that an adequate formal structure of management, supported by traditional values favourable to the maintenance of co-operation, can effectively limit the conflicts and problems arising from technical change. Without attempting to prescribe industrial policy, it emphasizes some of the principles which should guide an effective approach to the solution of the industrial problems which technical change in general presents. Given a favourable milieu of management–union relations, the problems common to most technical changes are not insoluble. Mostly they arise from the changes in occupational structure which technical development necessitates, involving not simply a decrease or increase in the number of jobs available, but also alterations in the proportions of employees of different levels and types of skill required.

None the less, the study affords definite evidence that most employees are more adaptable than is often assumed. More important, it emphasizes the necessity of agreed principles governing transfers and of adequate provision for those not re-absorbed. This, in turn, implies prior and effective consultation between management and union representatives; and incidentally it is suggested that transitional measures to provide for those who cannot at once be found alternative employment should be a joint responsibility of industry and the community, since both should gain from technical advance.

Here, the study is in line with much that has already been emphasized in discussions on automation, and in one of its rare specific references to automation the report suggests that the financial measures of the National Insurance Acts catering for employment in general may have to be reconsidered if developments in automation accelerate redundancy. In particular, more attention must be given to the effective utilization of older employees. This group is likely to suffer most heavily from technical change, and its satisfactory re-employment is all the more important in view of the rising proportion of older persons in the population. Foresight and long-term planning can clearly ease the problems of re-allocation of employees, particularly as developments following a technical change may create more jobs. The study lends as emphatic support to the comments of the Department of Scientific and Industrial Research's report on automation as it does to those who are urging the importance of technical education to increase the adaptability and flexibility of the technician and craftsman.

There are other problems, too, of longer-term and general interest. If the immediate problems arising in the re-allocation of a labour force are settled satisfactorily, problems of re-training may well remain; and as Mr. J. Wellens emphasized in his recent book, "Education and Training in Industry", industry must give increasing attention to training within industry. Moreover, as Lord Mills, the new Minister of Power, points out in his foreword to that book, such training is an important function of management, and education in technological matters has become an essential qualification for industrial management. We need many more administrators and managers with engineering and scientific backgrounds.

This is further emphasized in Dr. Scott's study, which points out that adjustment to a new job is not only a question of training; it also represents the reaction of the individual to new conditions in their entirety, and these he interprets in terms of his expectations and his past experience. The effective adjustment of a labour force to a new process, on which the successful assimilation of a technical change depends, thus requires an intimate understanding, on the part of the leaders concerned, of the factors involved in the pre- and post-change situations.

Technical change thus not only tends to increase the demand for technicians and craftsmen, and for adequate means of technical education to meet that demand; it also increases the demand for managers imaginatively alive to the human and social issues involved, as well as competent to evaluate the technical factors. There is indeed welcome emphasis here on the need for giving adequate attention to the provision of facilities for training craftsmen and technicians, including opportunities for part-time study, which the Government's present proposals for the expansion of higher technological education largely ignore. Provision of real opportunities for promotion from the ranks can make some contribution to easing the problems of recruitment as well as meeting the existing shortage of technicians and technologists.

The study does not, however, merely emphasize the need for more attention to the problem of securing an increased supply of technologists and competent managers and administrators. It points to the importance of the question of general education which is now being so widely discussed. At least by implication, it supports the soundness of Sir Alexander Fleck's contention in his Robert Boyle Lecture at Oxford last March, that the scientist entering business should bring with him at least some conception of the historical development of industry. It may be recalled that in his proposals for the development of the Manchester College of Science and Technology, Dr. B. V. Bowden has since stressed the value of a study of the history of science, and more particularly the history of technology, and expressed the view that courses based on the history of technology might take in the College the role traditionally cast for the humanities.

There is evidence in this study of technical change that such courses might well make the graduate who enters industry better fitted to deal with the problems attending technical change, and to appreciate the problems which management–union relations present to-day—the problem which Mary Follett discussed in "Dynamic Administration", which Elton Mayo described as the law of the situation and which Sir Frederic Hooper has discussed under the title of 'authority'. While Dr. Scott's study reinforces all that has been said as to the importance of increasing our supply of technologists and scientists and trained managers to enable Britain to hold her place in the world to-day, and no less of maintaining an adequate supply of craftsmen and technicians, adaptable as well as competent, above all it emphasizes the importance of quality. From whatever source the manager is drawn, he must be, as Sir Hugh Beaver has said, a citizen, capable not merely of assessing the technical and business factors of the enterprise for which he is responsible, but also of judging aright the needs and minds of the staff he controls and winning their whole-hearted co-operation. The universities and the colleges of technology have no greater responsibility than that of turning out men competent to face the technical and scientific issues, and also able to handle imaginatively and decisively the human and moral issues on which ultimately the smooth execution of technical change depends.

EARLY AMERICAN SCIENTISTS

The Pursuit of Science in Revolutionary America, 1735–1789

By Prof. Brooke Hindle. Pp. xi+410. (Chapel Hill, N.C.: University of North Carolina Press; London: Oxford University Press, 1956. Published for the Institute of Early American History and Culture, Williamsburg, Virginia.) 60*s*. net.

IN the period of this volume (1735–89)—and long after—the United States formed an outer periphery of European culture. They received far more than they gave, participated remotely (if not always humbly) in the scientific excitements of the age, and

were praised not so much for the importance of their scientific attainments as for their precocity. Franklin was the only American scientist of the Colonial period of international stature. Yet even Franklin's fame was in part romantic, and in middle life he was almost more European, physically and intellectually, than American. He stood above the petty endeavours and local squabbles of colonial practitioners and enthusiasts with only one possible rival, John Winthrop, of Harvard, who had a solid reputation in Europe as an astronomer.

Means and money for building reputations were generally lacking, though interest in science was not. When one thinks of the weight of scientific correspondence that traversed the Atlantic, of the election of American members to the European scientific academies, and of the success of the colonists in the revolutionary war, it is difficult to recall the narrowness of life even on the eastern seaboard. The colonists made no steel, nor gunpowder; they had no skilled glassworkers; even the type for their books and newspapers was imported. Many attempts by the British Government and colonial 'improvers' to establish new industries, such as sericulture, or to introduce the English agricultural improvements, proved abortive. European scientific books and journals were not readily available (though extracts were printed in the newspapers) and the main concern of the colonial colleges was the training of teachers and ministers of religion. Practically all scientific apparatus had to be bought in London. There was no public astronomical observatory; no mental hospital in the whole of north America before 1773. New York city still lacked a hospital of any sort at the end of the war. Not surprisingly, the best American physicians had been trained in Edinburgh.

Prof. Brooke Hindle has written an able account of American scientific activity in this formative time, when the will to independence grew triumphant and even scientific assemblies were divided by religious and political tensions. As he shows, scientific enthusiasm was tinged with patriotic ardour. "When I review the history of the world, and look on the progress of Knowledge, Freedom, Arts, and Science", wrote William Smith, "I cannot but be strongly persuaded that Heaven has yet glorious purposes to serve thro' *America*" (pp. 116–7). More truculently, Ezra Stiles, of Rhode Island, projected an 'American Anti-European Academy of Sciences' (p. 120). Inevitably, too, in public discussion emphasis was laid on the utility of science, though small fruits in fact resulted from its encouragement. But if America had little to offer in the way of conspicuous scientific achievement, other than Franklin's, the colonists had (the author emphasizes) an advantage denied to Europeans: they lived in a new continent. Their efforts in collecting new species and natural curiosities were not despised in Europe, though most of the systematic work was done there. Nor was the colonial share in observing the second transit of Venus in 1769 negligible, though again more enthusiasm than scientific exactitude was exhibited.

What emerges most positively from this book is the wide ramification of American scientific interest. Admittedly, this was often superficial—Brooke Hindle seems to have traced for his period almost every plant-hunter, every telescope, every newspaper paragraph having a scientific flavour. A good deal of his book is not far from the parish pump. Nevertheless, the size of the American Philosophical Society in 1769, the sums of money raised to aid the observations of Venus, the output of books and pamphlets, and the range of scientific correspondence from Georgia to New England are evidence of a wide scientific hinterland. In colonial America one can see how middle-class men, but moderately educated and distant from the main centres of activity, absorbed science and reacted to it. In Britain and Europe there were many more such amateurs, but they did not dominate the scientific scene, for they were overshadowed by the grandees of birth or achievement. In America a certain aspect of the growth of science in the West is perhaps more clearly apparent than elsewhere.

A good deal has been written on science in colonial America. In a comprehensive survey Brooke Hindle has used this well, with much study of original materials; indeed, to one English reader his book seems rather too long. Is it really essential to know how a screw, fitted to the Library Company's telescope, was paid for (p. 153)? Detail tends to obscure the most important features of the narrative, while the achievements of the leading figures tend to blend in with the careers of the third-rate and insignificant. Perhaps this is one result of an emphasis on persons and organization; another is a paucity of discussion of scientific ideas. If the complete absence of the names of Voltaire and Diderot (and one incidental reference to Hume) may be passed over, the neglect of Black and Descartes, for example, and the brevity of allusion to Cavendish, Lavoisier and others, seem surprising. Once it is realized, however, that this book deals with the scientists rather than the science of revolutionary America, its virtue of completeness is outstanding. It gives a full and usually interesting picture of the men who laid the foundations of American science, in the society which furnished their setting.

A. R. Hall

THE EARTH AS A PLANET

The Earth as a Planet

Edited by Gerard P. Kuiper. (The Solar System—Vol. 2.) Pp. xvii+751. (Chicago: University of Chicago Press; London: Cambridge University Press, 1954.) 94*s*. net.

This is the second of four volumes planned to provide scientists in general with a reliable outline of all the available information—and a guide to its sources—concerning the solar system. The study of the Earth, even in its more planetary aspects, calls for the co-operation of scientists of almost every kind, and the editor is to be congratulated on his team of sixteen authors, each of whom has made substantial contributions to the subject he has been selected to expound. The wide range of subjects discussed in this weighty volume is indicated by the following summary of the contents. The number of pages in each section is added in brackets.

"Dimensions and Rotation", H. Spencer Jones (41); "Dynamics of the Earth–Moon System", Harold Jeffreys (15); "Interior of the Earth", Edward Bullard (81); "Development and Structure of the Crust", J. Tuzo Wilson (79); "Oceanography", H. U. Sverdrup (43); "Geochemistry of the Crust", Brian Mason (41); "Atmosphere up to 30 km.", H. R. Byers (72); "Biochemistry of the Atmosphere", G. E. Hutchinson (63); "Absorption Spectrum of the Atmosphere", Leo Goldberg (57); "Density, Pressure and Temperature Data above

30 km.", Fred L. Whipple (23); "Emission Spectra of Twilight, Night Sky and Auroræ", J. W. Chamberlain and A. B. Meinel (62); "Physics of the Upper Atmosphere", D. R. Bates (68); "Dynamic Effects in the High Atmosphere", M. Nicolet (69); "The Earth as seen from outside the Atmosphere", Clyde T. Holliday (13); "Albedo, Colour and Polarization of the Earth", Andre Danjon (13); subject index (11); index of definitions (2).

A comparable team of reviewers would ideally be required to comment adequately on the vast array of data and interpretation here assembled. As it is, this particular reviewer can do scant justice to the contributions devoted to the atmosphere and its problems. A division into two sub-volumes could easily have been achieved, with obvious advantages to individual purchasers. The volume is beautifully produced and illustrated, but many of its users will feel that it is much too heavy to be read with comfort.

Much of the first half of the book will be of permanent value to geologists, more especially because recent and current geophysical discoveries are so surprising that they will inevitably lead to a drastic revision of former interpretations of the Earth's structure and behaviour. Bullard's chapter on the Earth's interior is particularly noteworthy in this respect. He remarks that "the earth is the only planet for which we have gravity or magnetic surveys or seismological observations or measurements of bodily tides or of heat flow", and proceeds to describe and discuss these fascinating topics with admirable clarity. Wilson then boldly tackles a formidable group of crustal problems on a world-wide scale, and with a remarkable originality of outlook. His chapter is a valiant attempt to synthesize megatectonics. It is notable for two leading suggestions: one, based on rates of erosion, deposition and vulcanism, that continents are growing at the expense of ocean basins; the other, based on the distribution and dating of orogenic belts, that the continents may have been growing more or less continuously during geological time. Judging by published reactions these far-reaching concepts appear to have gained more adherents than opponents; however, the next few years will probably see a more vigorous outburst of criticism, as some parts of the complex of hypotheses are admittedly vulnerable. Wilson himself warns the reader that the present is a time of changing ideas, and stresses the primary importance of the descriptive data. Whatever the outcome, this fresh and invigorating attack on old problems is greatly to be welcomed.

Geochemistry is treated with masterly precision by Mason, who discusses each stage in the geochemical cycle and also gives a brief but well-balanced account of current views on the Earth's origin and initial differentiation; and by Hutchinson, who is concerned particularly with life and the atmosphere, and such problems as photosynthesis, the carbon dioxide balance sheet and the nature of the atmosphere in Precambrian times. The rapid growth of oceanography has provided Sverdrup with much new data since his previous survey of the subject and his re-assessments of ocean current systems and heat circulation are especially valuable. Byers's general account of the atmosphere below the stratopause is probably unsurpassed as an introduction to a part of our planet about which far too little of what is already known has yet been realized by the non-meteorologist—to say nothing of the superstitions about rain and drought which still, like astrology, continue to excite the popular imagination. A series of eight long-range radar pictures illustrating the development of a hurricane over Florida, and showing a clear circular 'eye' surrounded by bands of rain-cloud echoes which move spirally inwards, is a most spectacular demonstration of the dynamic nature of a cyclone. Another impressive set of pictures is a magnificent series of rocket photographs (in the chapter by Holliday) which show the Earth's surface and cloud formations over areas of more than a million square miles. Other aspects of rocket research and the results achieved are reviewed by Whipple. The remaining chapters are mainly concerned with the physics, chemistry and dynamics of the upper atmosphere, and although Bates tells us frankly that "few of the problems can be regarded as satisfactorily solved", the wonder is that so much has already been achieved in the days before the first artificial satellites.

The geologist will probably look for information that may have a bearing on past and present glaciations, and careful search will certainly prove rewarding, though he may be disappointed in not finding any systematic treatment of this and other topics concerned with the behaviour of the Earth over long periods of time. But it is easy to ask for more, and in two sub-volumes more might have been practicable. However, two more volumes—on the planets and satellites—are still to come, and it is understood that the origin of the solar system is to be discussed in Vol. 4. The completion of this magnificent work is eagerly awaited, and meanwhile Prof. Kuiper and his contributors have already earned our warmest thanks and congratulations.

ARTHUR HOLMES

AN INTRODUCTION TO ANIMAL NAVIGATION

Animal Navigation

How Animals Find Their Way About. By Dr. J. D. Carthy. Pp. 152+18 plates. (London: George Allen and Unwin, Ltd., 1956.) 18*s*. net.

THE post-war years have seen much progress in several aspects of specialized animal behaviour studies in relation to orientation mechanisms and direction finding. A large proportion of this work has been limited to a few insects and birds, but in all a wide range of animal groups has been studied including bees, butterflies, locusts, fish, birds and mammals. The published material is consequently scattered in many different scientific periodicals and books and for this reason the non-specialist has found it difficult to keep abreast with the advance of knowledge. For some time there has been a need for a review or digest of the subject in terms readily understandable to the general biologist and layman and Dr. J. D. Carthy's book admirably fills this gap.

Dr. Carthy's view is a broad one; he opens with a chapter which puts his subject in perspective by relating navigation to the needs of man and animals. Succeeding chapters range from accounts on chemical sensitivity such as trail-finding, with special reference to Dr. Carthy's own work on ants; the fascinating experimental work on the homing of solitary wasps and direction finding and communication in the honey-bee; the navigation of birds and the migrations of butterflies, locusts, fish and mammals.

Although there is a great deal of literature on the subject of migration, Dr. Carthy only outlines the main features for each animal group mentioned and rightly discusses in some detail the recent experimental work carried out on the mechanism of navigation. This work centres largely on the importance of the Sun's position for direction finding and the increasing evidence of the receptiveness of the arthropod eye to polarized sunlight. Full credit is given to the remarkable work of von Frisch on the honey-bee and to Kramer and Matthews on birds.

In his final chapter Dr. Carthy stresses that there is no evidence that we need look further than the normal five senses for the mechanism of orientation and navigation in animals, but that one or more of these may be developed to a degree of sensitivity far beyond that found in man. The book is well illustrated with diagrams and photographs and the text presented in a lucid style which conveys Dr. Carthy's own enthusiasm for the subject. There is an index but the only reference to literature on the subject is a mention of four major works for further reading. It probably would have been helpful if some reference to the relevant literature had been made at the end of each chapter.

ERIC DUFFEY

THE WORLD OF PLANKTON

The Open Sea—Its Natural History

The World of Plankton. By Prof. Alister C. Hardy. (The New Naturalist: a Survey of British Natural History.) Pp. xv+335+48 plates. (London: William Collins, Sons and Co., Ltd., 1956.) 30*s*. net.

CONSIDERING the abundance of recent books on the seashore, it is surprising that so little has been written on the marvellous world of drifting life that lies beyond. The gap has now been filled by Prof. A. C. Hardy, Linacre professor of zoology in the University of Oxford, in one of the most attractive of the New Naturalist series.

To the plankton worker, nothing can be more fascinating than to examine a haul of living plankton with its myriad forms each busily moving on its own concerns. This fascination the author has tried to convey to the layman also, and if the reader will follow the simple directions in this book he will open up for himself a new world and will have here a reliable and most readable guide. For the student also it can be thoroughly recommended. Although not a text-book in the conventional sense, it is one of the best kinds of book to put into the hands of any student of marine biology; it gives him a wide view of a great subject yet shows him how much there is still to discover.

Plankton contains representatives of almost every animal phylum, some of them spending the whole of their lives in it, others only a short time as larvæ. Its distribution is world-wide and ranges from the surface to the ocean depths; it thus inhabits a great variety of environments. The study of plankton is bound up with study of water movements, with other sciences such as hydrography and biochemistry, and raises questions of ecology, adaptation and evolution which have not yet been answered. It touches economics too, for on the plankton depend the fisheries—the pelagic fisheries directly, the demersal indirectly. About all this the author has written with an enthusiasm which communicates itself to the reader on every page.

The book opens with an account of the water movements around the British Isles and, after chapters on the phytoplankton and its seasonal variation, describes the different forms of zooplankton. It includes details of the anatomy, habits and life-history of the common or important planktonic animals. In a chapter on pelagic larvæ many forms are described, together with their complicated metamorphoses, and there is a discussion of Garstang's theory of evolution by pædomorphosis, enlivened by some of Garstang's verse.

The account of the vertical migrations of zooplankton, a subject on which the author has himself done much work, summarizes the evidence and puts forward some interesting hypotheses, but still has to leave the cause as the major planktonic puzzle. There are chapters on life in deep water, and on light production by planktonic organisms. The cephalopods have a chapter to themselves, and the book concludes with a chapter on plankton and the fisheries. This may serve as an introduction to the second volume of "The Open Sea" which, we are promised, will appear shortly.

The author has cast his net widely, and when it makes his story more complete does not hesitate to include observations on creatures not usually found in British waters or even strictly planktonic. He has worked on plankton throughout his scientific career and his recollections of life on both the old and the new R.R.S. *Discovery* have enriched many pages of this book. He has also been responsible for, or closely associated with, so many of the recent developments in plankton work—plankton indicators and recorders, the plankton–herring programme, and vertical migration studies, to mention only a few—that his account has a vividness which it could not otherwise have.

The writing is simple and direct, enlivened by happy metaphors (the planktonic larva as a 'perambulator' for the developing adult is one instance) and by reminiscences of his voyages in many oceans. The book is well illustrated, mainly by the author's line drawings and charming watercolours and by Dr. D. P. Wilson's outstanding photographs.

When a reprinting is called for (and the book will certainly be popular), the opportunity should be taken to correct the numerous misprints.

SHEINA M. MARSHALL

MARRIAGE IN PRIMITIVE SOCIETY

Mariage et Équilibre Social dans les Sociétés Primitives

By Pierre Métais. (Université de Paris. Travaux et Mémoires de l'Institut d'Ethnologie, Tome 59.) Pp. xi+546. (Paris: Institut d'Ethnologie, 1956.) 4,000 francs; 15 dollars.

THIS formidable work is concerned with one of the classic themes of anthropological theory—the notion that marriage constitutes part of a continuing system of prestations between the kin of the husband and the kin of the wife. The argument is worked out primarily in relation to the Kamo of New Caledonia, and comparative generalizations are then applied to the Iroquois and the Arunta. The choice of these two particular societies gives an indication of the somewhat archaic nature of the work as a whole.

The theoretical ideas in the book are derived first from Durkheim and Mauss, and secondly from Rivers and Granet. The first half of the book, which is concerned exclusively with the Kamo, is based upon the author's own observations as well as those of Maurice Leenhardt. This contains numerous ethnographic facts of great interest. The other two sections of the book are based only on second- or third-hand sources. On the theoretical side, the author neglects completely almost everything that has been written since 1939.

Marriage provides the central theme, but the author is also concerned with examining the relationship between the structural categories of human societies on one hand and the categories of language and the natural environment on the other. In recent years the most significant anthropological contributions to this topic are those of Radcliffe-Brown and Lévi-Strauss. Dr. Métais gives no evidence of having read any work by Radcliffe-Brown published later than 1913; that of Lévi-Strauss is not mentioned at all. In the circumstances, a detailed discussion of the argument becomes superfluous. On the theoretical side the book is not so much wrong as out of date. However, the massive and careful assemblage of ethnographic detail and the excellent series of bibliographies are of real value. Those who find stimulus in Radcliffe-Brown's essay, "The Sociological Study of Totemism", published in 1929, will find plenty of relevant facts in Dr. Métais's book. It may well be that some careful reader will be able to make the theoretical advance which Dr. Métais himself has failed to make. E. R. LEACH

THE CHESSER REPORT

The Sexual, Marital and Family Relationships of the English Woman

By Dr. Eustace Chesser, in collaboration with Joan Maizels, Dr. Leonard Jones and Brian Emmett. Pp. xxxvi+642. (London: Hutchinson's Medical Publications, 1956.) 75*s*. net.

MANY of the so-called principles which form the basis of learning in disciplines like psychology, sociology and, even, education have been arrived at by empirical thinking, inspired guesswork or, too often, repeated utterance of what at one time may have appeared to be revealed truth. For this and other reasons this monumental survey of the emotional attitudes of English women towards marriage, the home and family life should be welcomed as an impressive scientific approach to sociological problems of major importance.

The study was undertaken with three aims in view. First, to discover experiences and attitudes towards marriage and sex relationships. Second, to relate the connexion between childhood and present experiences towards marriage and sex relationships; and thirdly, to discover those factors which are associated with feelings of happiness and unhappiness in marriage. It was not meant to be simply a classificatory, fact-finding inquiry, but was designed to test certain hypotheses suggested by sociological and clinical findings.

Touching, as they did, on the most intimate details of individuals' private lives, the investigators realized that, with all its deficiencies, only the use of a questionnaire would be likely to yield information approximating most closely to the truth. Considerable care was taken in the preparation of the questionnaire so that answers to certain sections could be checked and counter-checked for validity by answers to other sections. It is a tribute to all the six thousand married and single women taking part in the inquiry and to the way in which their co-operation had been ensured by all the 1,498 general practitioners from many parts of England that there were few discrepancies in any of the completed questionnaires. With all the limitations of the questionnaire technique and despite the relatively small sample of women who could not wholly be chosen at random, the survey can fairly claim to have uncovered much information about the private lives of English women which previously had been only suspected and often misrepresented.

The first part of the inquiry was concerned with childhood experiences and, while confirming many cherished beliefs, cast doubt on a number of others. It is not surprising to learn, for example, that the quality of parental relationships affected the childhood lives of those taking part in the inquiry more profoundly than any other factor. Nor is it surprising to learn that the death of the mother, and particularly in infancy, had a markedly adverse effect on childhood happiness. What is surprising is that the loss of a father seems to have had little effect on childhood happiness. The results of the analysis are also interesting in that they do not appear to confirm the assumption that 'only' children necessarily have a happier or less happy childhood than others. Doubt is also cast on such a genuinely accepted belief that really happy children are to be found in large families; in this inquiry the highest proportion of those who felt their childhood had been exceptionally happy was found among married women who had one to three siblings. In the case of single women, the highest proportion with very happy childhoods were 'only' children.

The second field of study deals with single adult life, and the third with married life. In both, interesting and important information is revealed and shows that the sexual emancipation of English women has proceeded much farther than had been suspected. This part of the book bears out many of Kinsey's findings in his investigation into the sex life of American women. It has greater value, however, in being more comprehensive. In the Chesser survey, for example, the influence of religion as the chief external authority for an explicit code of moral behaviour with regard to sex and marriage was clearly recognized, and careful inquiries were made into parental attitudes towards religion and parental religious practice; early religious education and church attendance; and present religious observance. The strength of the religious influence in the early home lives of the informants was then related to certain experiences in later life and to attitudes towards sex and marriage. The differing influences of certain denominational groups are not wholly unexpected, and may cause further questions to be asked about the role of autocracy in religion.

The documentation of the book leaves little to be desired, and its value is enhanced by a number of appendixes setting out specimen questionnaires, how they were distributed and analysed, and the names of all the doctors who collaborated in this inquiry. It should be of interest to all who are concerned with the promotion of better relationships between men, women and children. T. H. HAWKINS

History of American Technology

By Prof. John W. Oliver. Pp. viii+676. (New York: The Ronald Press Company, 1956.) 6.50 dollars.

IN writing what claims to be the first comprehensive historical account of American technology and invention, Prof. Oliver undertook a work of encyclopædic scope. It covers the whole range of American science and technology and their effect on the growth of American culture at large, and it is not surprising that it should be somewhat uneven in merit. On the whole, the first two parts are the best—those in which Prof. Oliver reviews "Yankee Ingenuity, from Jamestown and Plymouth to the American Revolution" and "Laying the Foundation, from the American Revolution to the Civil War". In the third part, in which he treats of the "Rise of the United States as a World Power, from the Civil War to 1900", the difficulty of maintaining uniformity of accuracy and treatment in detail becomes apparent, and it is even more so in the fourth part, on "World Leadership: from 1900 to the Present".

The blemishes, however, are minor and of detail, and such as should have been eliminated had Prof. Oliver shown his manuscript to a competent specialist. Any well-informed chemist would have been able to correct the confusion between pigments and vat dyestuffs, between antipyrites and antipyrin, or the statement about the preparation of nitric acid and ammonia from coal tar. Any rubber technologist would have helped him to get his reference to rubber a little tighter and more accurate, a textile technologist could have assisted in getting his treatment of man-made fibres in better balance, while in his account of the age of plastics Prof. Oliver is again not very happy and might well have been helped to reshape misleading sentences.

None the less, Prof. Oliver has written a notable and readable book. He never fails to see the wood for the trees, and he can depict succinctly and luminously the contribution of science to a particular technology. Nor does he overlook the way in which science and technology are communicated; some of his most valuable chapters touch on the growth of scientific and technical societies and means of publication. It is a factual account and not the philosophical study that Mumford essayed on an even larger canvas, and for that reason it is a pity that the bibliographical notes to the chapters should vary so widely in adequacy. R. Brightman

The Protozoa, Sarcodina

By Dr. Margaret W. Jepps. Pp. vii+183. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 30*s*. net.

PRIOR to the publication of this book, students requiring information on rhizopods have had to refer to the comprehensive volumes of the "Traité de Zoologie" and Reichenow's recent revision of Doflein's "Lehrbuch der Protozoenkunde". Dr. Jepps's book is based on a series of lectures given to senior students of zoology and provides a general survey suited to their needs. The didactic approach commonly found in such books is avoided and gaps in the knowledge of the morphology, biology and classification of rhizopods are indicated. The introductory chapter gives a brief review of protozoan morphology and physiology and is followed by a detailed account of the class Sarcodina. As the author herself admits, the systematics of these organisms are not settled and she adopts a classification into seven orders, Amœbæa, Foraminifera, Heliozoa, Radiolaria, Rhizomastigina, Protomyxidia and Mycetozoa. The morphology and life-history of representative organisms in each order are fully described and illustrated, followed by a brief account of the taxonomic classification in those orders where this has been worked out. Ecological aspects of each group are not neglected; thus a detailed account is given of parasitic species in Amœbæa and Mycetozoa, including the host–parasite relationship. Attention should be directed to an ambiguous footnote (p. 87) which states that "the originals [of the illustrations of Brady's book on Foraminifera] are preserved in the British Museum (Natural History)". This refers, of course, to the original foraminiferan shells.

The book is supplemented by an extensive bibliography. Reference is made to recent publications from which it is possible to trace the original literature. The text is well illustrated by line drawings, though it is unfortunate that the standard of reproduction is uneven. Although addressed to senior students, it will also prove useful to those workers requiring a general survey of the Sarcodina.

R. A. Neal

The Physics of Nuclear Reactors

A Conference arranged by the Institute of Physics in London from 3 to 6 July, 1956. (*British Journal of Applied Physics*, Supplement No. 5.) Pp. iv+112+xvi. (London: Institute of Physics, 1956.) 25*s*.

THE British Nuclear Energy Conference set up by the four professional engineering institutions and the Institute of Physics has undertaken the task of disseminating among its members information on the developments in the nuclear energy field. In pursuance of this policy, symposia on the engineering aspects of reactor technology have now been followed by the Symposium on the Physics of Nuclear Reactors organized by the Institute of Physics. The proceedings of this symposium appear as a *Supplement* to the *British Journal of Applied Physics*.

In the opening address, Sir John Cockcroft surveys the scientific problems in the development of nuclear power. These range from the accurate determination of nuclear parameters vital for the design of reactors with optimum fuel utilization, to the chemical and metallurgical problems of material compatibility. J. R. Dietrich, Argonne National Laboratory, United States, gives a paper on the physics of advanced reactors containing interesting new information on the experimental boiling water reactor (EBWR) and the fast breeder reactor (ZPR. III). Two other papers on reactor physics by P. W. Mummery and L. R. Shepherd follow; the former on experimental reactor physics stresses the continued importance of integral measurements with the present lack of accurate nuclear data, the latter describes the zero energy fast breeder reactor, Zephyr. The value of a reactor as a research tool in solid state physics is brought out by A. H. Cottrell and the contributors to the discussion of his paper on the irradiation effects on the physical properties of materials. The ancillary problems of reactors, such as shielding, control and instrumentation, are covered by papers by E. C. Laurence, A. J. Salmon and W. Macrae. The concluding papers are devoted to surveys of the role of chemistry and metallurgy in a nuclear energy project by R. Spence and L. Rotherham, and to discussion of the design of research reactors opened by W. B. Lewis and F. W. Fenning. W. K. Mansfield

THE IONOSPHERE*

By J. A. RATCLIFFE, O.B.E., F.R.S.
Cavendish Laboratory, Cambridge

Radio Exploration of the Ionosphere

IN the usual method of ionospheric sounding, short trains of radio waves are sent vertically upwards and received at the ground after reflexion in the ionosphere. From the measured time of travel the equivalent height (h'), at which the waves would have been reflected if they had travelled throughout with the free-space velocity, is then calculated. The wave-frequency (f) is altered and a record of $h'(f)$ is made which shows how h' depends on f. The actual group-velocity of the short wave-train is, in fact, different from the free-space velocity, so that the actual height of reflexion is not the same as the equivalent height.

If the frequency is increased far enough it is found that, at one or more frequencies, the $h'(f)$ curve takes a sharp upwards bend, and for frequencies greater than this 'critical' frequency, the reflexion is either from a higher level, or there is no reflexion at all. These critical frequencies correspond to the penetration of layers of electrons in the ionosphere. It is possible to distinguish an E layer near 100 km. and an F layer near 250–300 km., and sometimes the F layer is partially divided into an upper ($F2$) and a lower ($F1$) layer.

The critical frequency of a layer is related in a simple way to the electron number-density at the peak of the layer, so that it is of interest to find how it varies with time of day, season of the year, and geographical position.

A theory which supposes that an ionospheric layer is formed by the ionizing action of a radiation emitted by the Sun leads to the conclusion that there should be a simple relation between the peak rate of production of electrons and the angle of incidence of the solar radiation. The number-density (N) of electrons at any one time depends both on this rate of production and also on the mechanism which removes the electrons, which might be a recombination process, with a rate proportional to N^2, or an attachment process, with rate proportional to N.

Observations of the critical frequencies of the E and $F1$ layers at different places, seasons and times of day have shown that the simple theory of layer formation is approximately correct, and that in those layers the process of electron loss is one of recombination.

When the critical frequency of the $F2$ layer is studied, however, its behaviour is quite unlike that to be expected on the simple theory. The variation over the Earth, through the seasons, and through the day, all seem to be anomalous. In the past few years attempts have been made to understand these anomalies by studying the electron distribution throughout the whole of the layer, and not only at the peak. This study has involved the whole of the $h'(f)$ curve.

Determination of the Electron Distribution

It is clear that the shape of the $h'(f)$ curve depends on how the electron density (N) varies with height (h) in the ionosphere, and it is surprising that so little effort was made, until recently, to extract information about the form of the $N(h)$ curve which relates these two quantities. The reasons are probably twofold: first, the results are to some extent ambiguous if there is a layer with a separate peak underlying any other part of the ionosphere, so that there is a 'dip' in the $N(h)$ curve; and secondly, the deduction of the $N(h)$ curve from the $h'(f)$ curve involves the numerical solution of an integral equation which was considered to be unduly tedious. In recent years, on one hand, it has been realized that the ambiguity need not be important for first-order theories, and, on the other, several workers have developed methods for performing the computations expeditiously.

Once the electron distribution was known, it became apparent that the major anomalies in the $F2$ layer were much less marked if the total number of electrons in the layer was considered, instead of the peak electron-density. This fact led to the suggestion that the radiation ionizing the $F2$ layer might behave in quite a normal manner, but that some large-scale vertical movements might redistribute the electrons; indeed, it became clear that when the layer was thicker than normal the peak number-density was smaller, and *vice versa*.

A detailed consideration of the electron distribution has also shown that the $F2$ layer is probably not caused by a separate ionizing radiation with a peak of production near that layer, but by the radiation which has its peak of production at the level of the $F1$ layer. This comes about as follows. The electron density at any given level depends both on the rate of production and on the rate of loss of electrons; now the rate of production decreases upwards above the peak of the $F1$ layer, but the rate of loss decreases even more rapidly so that the resulting electron density *increases* upwards. If that were all it would increase without limit, and there would be no peak to the $F2$ layer. If there is to be a second maximum of electron density corresponding to the $F2$ peak, then, at greater heights, either the upward increase of the loss-coefficient must be less rapid, or some other mechanism, such as diffusion, must be important.

Arguments of this kind, and the examination of the detailed $N(h)$ curves, are at present leading to a better understanding of the $F2$ layer, and particularly to a realization that the existence of a peak in that layer is somewhat fortuitous, so that its anomalous behaviour is not surprising.

Movements in the Ionosphere

A wave reflected from the ionosphere is found to undergo more or less rapid variations of amplitude and phase, usually termed fading. Examination of the fading at points on the ground separated by about one wave-length has shown that there exists, on the ground, an irregular and constantly changing wave-pattern. These facts imply that there are changing, and moving, irregularities in the electron distribution in the ionosphere, and it should be

* Based on a series of four lectures given at University College, London, on November 6, 13, 20 and 27.

possible to use diffraction theory to determine their nature. Some progress has been made along these lines and in particular the regular horizontal drift movements have been measured. They are found to vary in the same kind of way at distant places, and it is hoped that the observations planned for the International Geophysical Year will lead to an understanding of their distribution over the Earth.

It is thus clear that both horizontal and vertical movements are important in the ionosphere, and attempts have been made to explain their production in terms of electrodynamic forces. These probably originate in a rather complicated way as follows. The gravitational attraction of the Sun, assisted perhaps by its heating effect, produces horizontal movements of the air at a level somewhere near 100 km., and as these movements drag the electrons with them, through the Earth's magnetic field, they build up electrostatic charges near that level. The electric fields of these charges, acting upon the electrons in the *F* region, higher up, again in the presence of the Earth's magnetic field, produce movements in that region. It is as though a dynamo in the *E* region, driven by the Sun, produces an electric field which drives a motor in the *F* region. It is probable that the vertical movements which lead to the anomalous behaviour of the *F*2 layer are caused, at any rate partially, by the 'motor effect'. It has not yet become clear whether movements resulting from a heating of the *F* region are also of importance.

The observable horizontal movements in the *E* layer are probably determined by the motion of the air in that region, but those in the *F* region are almost certainly caused by the 'motor-effect'.

The Ionosphere and the Sun

The behaviour of the ionosphere during eclipses can be used to investigate more fully the nature, and the source, of the solar radiation. The timing of the ionosphere eclipse shows that the radiations travel with the speed of light and are presumably ultra-violet or X-radiations. The precise behaviour during an eclipse has been used both to deduce the magnitudes of the recombination coefficients in the *E* and *F*1 layers, and to investigate the way in which emission of the radiations is distributed over the solar disk. It is found that when the Sun is quiet the emission is somewhat concentrated around the equator, and when it is disturbed areas of strong radiation are sometimes detectable, coincident with optically disturbed regions.

The ionizing radiation from the quiet Sun is found to vary considerably with the solar cycle, so that it presents a marked contrast to the visible radiation, which varies only little.

Sudden short-lived disturbances sometimes occur in the ionosphere on the sunlit side of the Earth at the same time as solar flares observed with the aid of spectroheliosccopes. These disturbances, known as 'sudden ionosphere disturbances', correspond to an increase in the electron content of the lowest part of the ionosphere where the collisions of electrons with neutral molecules are most frequent. Since the absorption of a radio wave depends on these collisions, there results a sudden decrease of the strength of signals. The resulting 'sudden fade out' often interrupts communications over the whole of the sunlit part of the Earth. Fortunately, these disturbances usually last only for a short time, of the order of 10–30 min.

Another type of disturbance, called an ionosphere storm, affects particularly the electrons in the *F*2 layer and often causes serious disturbance of communications, particularly because it can occur by day or by night and can last for hours or even days. It is probably produced by the arrival of charged particles in the polar regions, where they modify the current system of the 'atmospheric dynamo' in the *E* region, and incidentally produce visible auroræ. The 'atmospheric motor' in the *F* region is then set in motion, so that the electrons there are redistributed. It is the effects of changes in the *F* layer which are most noticeable in low and medium latitudes; at high latitudes the arriving particles produce increased numbers of electrons in the low ionosphere and there is often strong absorption, which in extreme cases can cause a 'polar radio blackout'.

It has been established that an ionosphere storm frequently follows a large 'sudden ionosphere disturbance' after about 36 hr., as though the solar flare, occurring at the time of the disturbance, emitted a stream of particles which took 36 hr. to travel from the Sun to the Earth. It is also known that ionosphere storms tend to recur after 27 days, the time of one solar rotation. These two facts have been used in attempts to forecast the occurrence of ionosphere storms, but so far only with partial success.

Ionospheric Scatter Propagation

The two main parts of the radio spectrum, the low-frequency and the high-frequency, each came into use for communication purposes through a discovery which, at the time it was made, appeared to contradict existing theories. In 1901 Marconi, working in the low-frequency part of the spectrum, tried to signal across the Atlantic in spite of the fact that all existing theories would have discouraged him. He succeeded only because there existed the ionosphere, hitherto unknown and unexpected. In 1925 it was thought that high-frequency waves, in the region of 10 Mc./s., were of such little commercial use that they were allocated to the amateurs for experimental purposes. The amateurs promptly showed, contrary to expectation, that they could be used for communication around the Earth.

Recently, another region of the radio spectrum, the very-high-frequency region, has been opened up for long-distance signalling; but this time the usefulness was foretold from knowledge of the ionosphere—it did not come about by chance. From observations of the irregular fading of waves it had been concluded, as previously explained, that the electrons in the *E* layer were irregularly distributed. It was therefore suggested that if a powerful beam of radiation were sent through that region on a frequency which would penetrate it, a useful amount might be returned to a distant point by a process of scattering from the irregularities. This was found to be the case and there now exist several of these 'ionospheric-scatter' communication channels working on frequencies in the neighbourhood of 50 Mc./s. They have the great advantage that they are unaffected by sudden ionosphere disturbances or ionosphere storms; first, because the high-frequency is not appreciably absorbed even under polar blackout conditions, and secondly, because the *F* layer, which is so strongly affected by a storm, plays no part in their propagation.

A GREGARIOUS FACTOR IN THE NATURAL CONDITIONED SALIVARY REFLEXES OF SHEEP

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LORENZ[1] has pointed out considerable limitations in the knowledge likely to accrue from the Pavlovian type of experiment on conditioned reflexes. Principally, these stemmed from the fact that the animal was isolated from stimuli other than the one chosen by the experimenter, and this restraint impeded the recognition of innate patterns of behaviour. Katz[2], in emphasizing the importance of observing animals at liberty in their natural environment, stated that "the more one restricts the conditions of response, the more specialized will the animal's behaviour become: finally one gets to the point where the animal, so to speak, no longer behaves as a complete organism but only as a bit of itself. In the Pavlovian 'conditioned reflex' method the salivary gland of dogs is isolated by a surgical operation. The reactions of the gland to certain situations can thus be followed exactly. But can one still call this a response of the *animal*? Is it not really the reaction of an isolated psychophysical mechanism to which the animal's body happens to be attached?" While Lorenz's comments on the limitations of the orthodox conditioned reflex experimental situation are essentially valid (as are Katz's remarks as they bear on this point), the above statement would appear to reflect a misunderstanding of the potentialities inherent in the Pavlovian method of systematically preparing an animal by aseptic surgery so that physiological functions hitherto concealed from easy access may be easily measured in the conscious undisturbed animal. Field observations of an animal's behaviour may reveal a complex motor pattern; but it is not inconceivable that the response of the animal in a specific field situation may also involve, for example, change of motor and secretory activity of viscera[3]. Though concealed, such changes would be nevertheless part of the total response of the animal to a natural situation, no less than that of the skeletal motor system.

This article describes three years study of a colony of thirty sheep prepared with a new type of permanent parotid fistula[4] in which it has been contrived by a plastic operation that the papilla and terminal 3 cm. of a parotid duct are enfolded in a skin teat, and the parotid saliva drips from the dependent point (Fig. 1). Hitherto, Scheunert and Trautmann[5] had been unsuccessful in making Pavlov–Glinski fistulæ in sheep, and numerous Russian workers[6–12] investigating salivary secretion in ruminants had, because of the technical difficulties, resorted to cutting the parotid duct in the cheek and transplanting the cut end into a stab wound. The disadvantages (duct stenosis, etc.) consequent on neglecting Pavlov's principle of preserving the papilla have been described by Kvasnitsky[13]. The new Wright operation permits secretion-rate to be unobtrusively recorded without the attachment of any apparatus to the animal. Thus the important advantage accrues that this index of response to distance receptor information can be conveniently used when the animal is in the company of other sheep. Further, parotid secretion in the sheep is continuous. Whereas in the dog a response may be measured by whether or not secretion occurs, in the sheep an environmental event may cause either increase, decrease or no change of the continuous secretion. Evidence to be presented suggests that the direction of change may be related to the cortical and affective reaction to the particular distance receptor information, and the results reveal a visceral component in the animal's response to the social stimulus of other sheep eating.

While Colin[14] denied a psychic effect on secretion in ruminants even though the animal was very hungry, Ellenberger and Hofmeister[15] took a contrary view. On the basis of experiments on sheep with cannulated ducts, Scheunert, Krzywanek and Zimmermann[16] agreed with Colin. Kudriavtsev and Anurov[7] found no psychic secretion of parotid saliva when the sheep were teased with food. Blokh[9] found that parotid secretion in the bull was continuous; but the submandibular secreted only during eating. He demonstrated that the sight of food or the arrival of the usual attendant evoked mandibular secretion, and a large decrease in continuous parotid secretion. This type of reflex effect on parotid secretion was

Fig. 1. *P.F.*16, Merino wether. The sheep has a Wright parotid fistula on the left side, and it also has bilateral carotid loops

observed in the goat by Tikhomirov and Fomin[17], and confirmed in cattle by Krinitsin[18]. Fomin[19], however, reported that, in elaboration of a conditioned parotid secretion in the calf, there were three stages of effect in which the selected artificial stimulus (metronome sound) respectively decreased, had no effect and then increased parotid secretion. The oft-quoted view of Colin, linked as it has been with the erroneous belief of Eckhard[20], that cutting the parasympathetic nerve to the parotid gland of the sheep does not affect the secretion-rate[21], has influenced the direction of some important investigations. For example, Liddell[22], who has done outstanding work on the induction of experimental neurosis in sheep, after describing his initial acquaintance with Pavlov's work as a result of a visit by Anrep in 1923, remarks that "sheep and goats, as cud-chewing animals, salivate continuously; hence we were unable to study salivary conditioned reflexes". N. F. Popov[23] also states that, in studying the conditioned reflexes of farm animals, the method by which conditioned reflexes were elaborated on a motor defensive basis was more applicable because of the peculiar aspects of horses' and ruminants' parotid secretion.

Our interest in this was aroused by a particular observation. Our colony of sheep with parotid fistulæ are kept in a large laboratory. The sheep can easily see one another, and during the day members of the Department are frequently moving in and out of the laboratory. Several sheep were in metabolism cages and others were in smaller cages which are on wheels to facilitate cleaning. A fistula had been made on a rather shy horned Merino wether (*P.F.*11) and for three or four days after operation, unlike most sheep, it had taken little food and its fistula secreted very slowly (about 1–3 drops/min.). Another cage containing a large, greedy Suffolk sheep (*P.F.*9) was moved next to that of *P.F.*11, so that the Suffolk sheep could just reach across and eat the fresh green lucerne which had been for some time in the food bin of *P.F.*11. *P.F.*11 observed this, and after about one minute its fistula commenced to secrete rapidly—after two or three minutes it ground its teeth and then commenced itself to eat. We observed, also, that our sheep quite clearly knew certain members of the Department and responded vocally to their entry into the laboratory, particularly if it were a person who usually fed them and he went in the direction of the food bin. When new to the laboratory, the secretion-rate of a sheep decreased when it was approached by the attendant. After some weeks, the rate increased when the attendant was carrying food and, afterwards, of itself the entry of the usual attendant into the laboratory evoked a sharp increase of secretion-rate (Fig. 2). After a time, some animals became conditioned to particular objects. For example, the sight of the weighing pan of the scales excited an increase of secretion-rate. The length of time the animal had been in the laboratory and its familiarity with the usual attendants were important in the type of reaction shown by the parotid gland as an effector organ. However, there were some sheep the parotid secretion of which always decreased though evidently excited by the sight of food. If the particular person who entered the laboratory left again within a minute, the secretion-rate, which had risen sharply, returned immediately to basal continuous rate. If green lucerne were carried in and placed in the animal's field of vision, the rise of secretion-rate was sometimes sustained for a considerable time (Fig. 3). The sheep stretched out and endeavoured to reach the food. Sometimes, after several unsuccessful attempts, it commenced licking and nibbling at the stainless steel floor of its cage. The increase of secretion-rate was seen more consistently when the lucerne was fed to sheep in adjacent cages, and the sheep under observation saw and heard the others eating (Figs. 2, 3 and 4). The rise of secretion-rate of the observed sheep continued until the attendant re-entered and removed the food from the next sheep, whereupon the secretion-rate usually returned to basal after 5–10 min. (Figs. 2, 3 and 4). Sometimes the increased parotid secretion was associated with evident dropping of mucous saliva from the mouth. If, prior to this, the animal were satiated and had paid little attention to the bin of chaff beside it during the previous hours, subsequent to making neck-stretching movements towards the apparently desired fresh lucerne which its colleague was noisily eating, it would vigorously start eating chaff (cf. Bayer[24]).

The fact that the psychic augmentation of secretion could be protracted (Figs. 2, 3 and 4) and could involve an increase of 60–100 ml. in the amount of

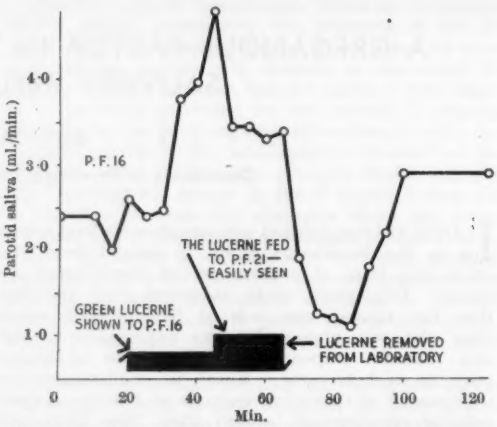

Fig. 3. *P.F.*16. The effect on parotid secretion of placing green lucerne in view of *P.F.*16. After 25 min. the attendant re-entered and gave the food to *P.F.*21, who could be seen easily by *P.F.*16. 20 min. later the attendant re-entered and removed the food from the laboratory

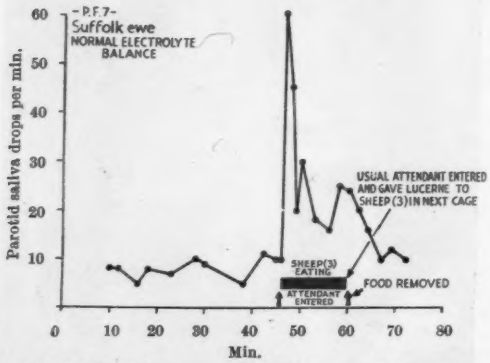

Fig. 2. *P.F.*7, Suffolk ewe. The effect on parotid secretion-rate of the entry of the usual attendant into the laboratory. The attendant gave fresh lucerne to sheep No. 3, and left within one minute. He re-entered 15 min. later and removed lucerne from sheep No. 3

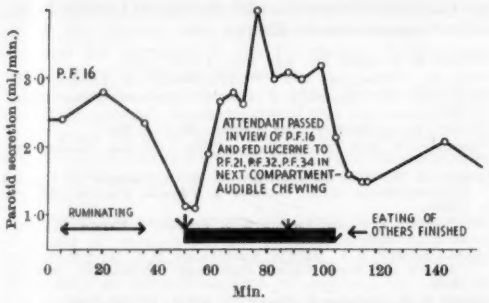

Fig. 4. *P.F.*16. The effect on parotid secretion of feeding green lucerne to three other sheep which were behind a partition, but whose chewing was easily audible. During the first 35 min. the animal was ruminating but the rate returned to basal (1·0 ml./min.) during the 15 min. prior to entry of the attendant

saliva secreted in 30 min. indicated that it was predominantly a parasympathetic motor response, and not a sympathetic effect causing expulsion of preformed saliva[21]. This was substantiated by the fact that it also occurred in an animal (*P.F.*16) in which the sympathetic innervation of the parotid had been extirpated[25]. Foot stamping, bleating, teeth grinding and onset of rumination sometimes occurred while the other sheep were eating.

Preliminary investigation of the psychic augmentation has endeavoured to determine whether the components of the exciting situation, that is, the sight, sound or possibly smell of the other sheep eating, were in themselves effective. To this end we compared the sight of food with, for example, the effect of feeding a number of animals which were on the other side of a partition but whose chewing was clearly audible (Fig. 4).

Table 1. *P.F.*13. The Inhibition of Parotid Secretion-Rate of a Sheep produced by taking the Animal from its Cage, and lying it on its Side upon a Table

Time (min.)	Vol. (ml.)	Rate (ml./min.)	Remarks
10	15	1·5	Standing in cage
29	3·1	0·1	Gently secured on table
10	17	1·7	Returned to cage
5	23	4·6	Eating fresh lucerne

Conversely, there were certain procedures which inhibited secretion. The most common one in our laboratory was the procedure of taking the animal out of the cage and gently securing it upon its side on the laboratory table (Table 1). In a novice sheep this could cause secretion to stop completely for 10–100 min. This inhibition was associated with a 20–30 mm. mercury rise of systolic blood pressure. The effect was immediately reversed by an intracarotid infusion of acetylcholine. It did not occur at all in a well-trained sheep which had had the procedure carried out frequently. It seems probable that the inhibition was largely a cervical sympathetic effect, as it occurred in bilaterally adrenalectomized sheep but was largely abolished when the procedure was carried out two months subsequent to extirpation of the ipsilateral superior cervical ganglion and no effort had been made to train the animal in the interim. That a factor in inhibition of secretion could, however, be reduction of parasympathetic secretory impulses was suggested by a number of different experiments, of which Fig. 5 is an example. The act of bringing a dog into the laboratory caused as large an inhibition of secretion in *P.F.*16, with parotid sympathetic connexions extirpated, as it did in other animals (for example, *P.F.*7) with intact cervical sympathetic.

While the inquiry is far from complete, the experiments show that pertinent distance receptor stimuli may alter parotid secretion in the sheep, and it would seem likely that the laboratory demonstration of a gregarious component in the salivary reflexes reflects a feature of field behaviour. All the sheep had spent 2–5 years in a herd on pasture before being used for these experiments.

Olnyanskaya[26] has shown that the oxygen consumption of sheep is increased during ingestion and rumination. The oxygen consumption of a fasting sheep is also significantly increased by the sight of other sheep eating or ruminating, and this effect was accentuated when the sheep were on pasture[27].

Reports of the work of the Laboratory of Ecological Physiology of the Pavlov Institute included interesting experiments by Fayziev and Uzhdavini[28], which also indicated a gregarious component in the salivary reflexes of sheep. The workers subscribed to the view of earlier Soviet workers[9,29] that the action of natural stimuli (for example, the showing of food; the arrival of serving personnel) induced a reduction of parotid secretion of the ruminant. They recorded, however, that sometimes augmentation of secretion occurred, and held that the variation was probably explained by variation in the functional state of the gland at the time of the experiment. Fayziev and Uzhdavini confirmed that there was no secretion from the submandibular gland other than during ingestion of food. They found, however, in the course of driving the sheep to pasture, that the sheep commenced to secrete when they saw the other members of the herd grazing. Secretion was measured by change of weight of cotton-wool tampons applied to the fistula orifice. The amount evoked by the natural conditioned stimulus was small relative to that caused by the unconditioned stimulus of eating, this being in contrast to what has been described above for the parotid gland.

There is other evidence to suggest that these indications of a gregarious component in natural conditioned salivary and metabolic reflexes may be

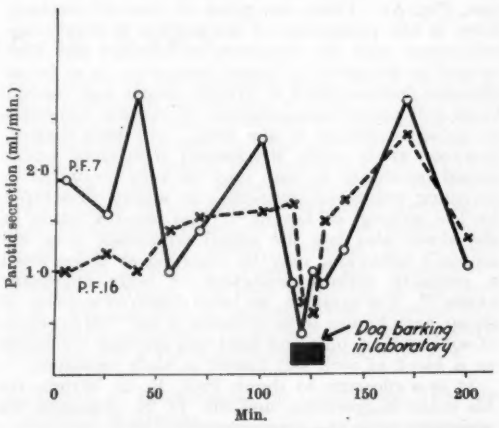

Fig. 5. *P.F.*16 and *P.F.*7. The effect on parotid secretion of bringing a dog into the laboratory for 15 min. *P.F.*16 had the ipsilateral superior cervical ganglion extirpated, and the cervical sympathetic had been sectioned in the neck

pertinent to field feeding conditions. For example, during a pasture trial by Southcott, Roe and Turner[30], groups of two, four, eight and sixteen sheep were placed in adjacent sections of a divided area. Whereas the others grazed over the whole of the allotted area, the group of two remained close to the fence within easy sight of their nearest fellows, neglected the periphery and, over a period of time, lost weight. If two groups of two sheep were put in adjacent sections, they grazed up and down the fence together and produced a distinct path. The experiments suggested that four sheep constituted a quorum. Turner[31], in the course of examining the cause of death after wheat feeding of drought-stricken sheep, found that, while he could reproduce the phenomenon on a field station, he could not do so in the laboratory with comparably starved sheep in separate pens. They would not eat enough wheat. Trotter[32] in his book on "The Instincts of the Herd in Peace and War" points out the advantages of the gregarious habit in pursuit, or sensitivity to alarms. In sheep, the latter would be relevant to the time an individual animal might spend grazing, being to some extent dependent on other sentinel sheep to signal danger, and being reinforced in its feeding by the sound and sight of other sheep similarly engaged. Field observers report that sheep commonly graze as a flock towards the direction of the wind. Trotter proposed "that each separate member of a gregarious species inherits characters deeply rooted in his being which effectually differentiate him from any non-gregarious animal" and "they will ensure his responding in a specialized way which will be quite different from the response of a solitary animal". He held that a simple example, observed by all, was the leisurely feeding of the cat as compared with the voracious eating of the dog which, to use a slang term with a sound biological basis, 'wolfs' its food.

Contrary to the view of Fayziev and Uzhdavini[28] cited above, it would seem that whether the secretion increases (Fig. 4) or decreases (Fig. 5) is in some way related to the cortical and affective reaction to the information of the distance receptors. It seems unlikely that such visceral responses would be absent in the field. Interpretation is sometimes complicated by the fact that secretion may vary as a result of interoceptor stimuli (for example, onset of rumination, Fig. 4). From the point of view of method, there is the possibility of integration of Pavlovian techniques with the approach of Lorenz[1] and Tinbergen[3] to the study of innate behaviour, in so far as effective devices fitted to Wright fistulæ and carotid loops will permit measurement of visceral responses to social situations in the field. For that matter, however, study while the animal is in close accustomed proximity to man may be very profitable in revealing behaviour patterns, as amply illustrated by the writings of Lorenz[33]. The parotid fistula in the sheep also has the added advantage that the animal's behaviour may be observed at times when a precisely defined distortion of body chemistry exists[4,34]. For example, we have observed a group of sheep, each known to be depleted of 500–700 m.equiv. of sodium ions, butt and fight one another for access to a block of rock salt placed in their enclosure.

It is a pleasure to thank Prof. R. D. Wright for his many suggestions, and Mr. D. K. Johnston for assistance with the experiments.

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OBITUARIES

Vice-Admiral John Dodd Nares

The announcement of the death on January 18 of Vice-Admiral J. D. Nares was received with deep regret by all who knew him; the younger son of Admiral Sir George Nares, he, like his father and elder brother George, chose the Navy as his career and joined the training ship *Britannia* as a naval cadet. In 1898, being by that time a sub-lieutenant, he was appointed to the *Triton*, and there commenced his association with the surveying branch of the Navy in which he continued to serve during the whole of his time on the active list.

After a brief period in home waters, Nares was appointed to the *Penguin* and for the next eight years remained on the Australian Station, assisting in surveys of New Zealand, Queensland and Tasmania. Returning to England in 1907, Nares next went to the *Research* for a season, and a year later joined the *Egeria* in British Columbia. In 1910 he

succeeded to the command, and on the final paying off of the *Egeria* was appointed to command the *Fantome* for surveys in the Buccaneer Archipelago on the west coast of Australia.

Promoted to commander in 1913, Nares served in the Hydrographic Department of the Admiralty until 1917, when he took command of the *Enterprise* and distinguished himself during naval operations on the coast of Palestine, for which service he was awarded the D.S.O.

In 1919 Nares was promoted to captain and, after a period of service in the Mediterranean and Red Sea in the *Enterprise* and the *Merlin*, returned to the Admiralty as superintendent of charts. In 1923 he was surveying the West African coast in the *Endeavour* and in 1925 became assistant hydrographer of the Navy until 1928, when he took over the *Iroquois*, surveying the Straits of Malacca. His final active service was once again as assistant hydrographer, and on promotion to rear-admiral he was placed on the retired list.

During 1931–32 Nares executed surveys of Bharanager Channel on the west coast of India.

In 1932 Admiral Nares was elected president of the Directing Committee of the International Hydrographic Bureau at Monaco, and re-elected in 1937 and 1947, and was a director until his death. At the request of the Admiralty, he remained at his post in Monaco until France was overrun by the Germans, and he then rejoined his old department at the Admiralty, serving as assistant hydrographer and in the rank of captain.

During his twenty-five years association with the International Hydrographic Bureau, Nares and his co-directors maintained the high prestige of the Bureau, and the technical and scientific publications produced continue to be of great benefit to navigators, hydrographers, oceanographers and geodesists of all nations. Nares himself took every opportunity to attend international conferences all over Europe, and his great willingness to help was also thoroughly appreciated by his colleagues and those who sought his assistance and advice. Although he would have been the first to disclaim any title to brilliance, Nares's work in the hydrographic field was of sterling worth and always dependable. His kindly disposition and ability to mix with the people of other nations endeared him to all who came in contact with him. He was never guilty of a mean action and was, in fact, an example of what an English gentleman should always strive to be.

Nares married Adeline Chaffey, daughter of the Hon. Mr. Justice McIntyre, of Hobart, Tasmania, who survives him together with a daughter. His only son, Alastair, was killed in action while serving in the Fleet Air Arm. J. A. EDGELL

Mrs. Watson Davis

MRS. HELEN MILES DAVIS, editor of *Chemistry* and wife of Watson Davis, director of Science Service and editor of the *Science News Letter*, died on January 25, at the age of sixty-one.

Born in Washington, D.C., on April 13, 1895, Mrs. Davis graduated from George Washington University College of Engineering with a B.S. in chemistry degree in 1918. She specialized in the popularization of science, especially chemistry, and the history of science. Since 1944 she had edited *Chemistry*, a magazine which is used especially in high schools. The following books were written or edited by her: "The Chemical Elements", "Scientific Instruments You Can Make", "Atomic Facts", "Science Exhibits", "Chemistry Show Book", "Exhibit Techniques". Her compilation of "New Laws of Matter" has run through five editions since its compilation just after the announcement of the first use of the atom bomb.

As chemistry writer for Science Service, she reported the Geneva Conference on the Peaceful Uses of Atomic Energy (1955), an atom bomb test, and numerous meetings of the American Chemical Society and other scientific societies. She often travelled with her husband when he was attending scientific gatherings outside the United States, and had accompanied him several times when he visited Britain.

She was a member of the American Chemical Society, Chemical Society of Washington, the Congressional Press Gallery, Sigma Kappa Sorority and the Eistophos Club.

NEWS and VIEWS

Atomic Energy for Peaceful Purposes: Liaison between London, Paris and New York

SPECIAL offices to facilitate the exchange of information between British and American atomic scientists have been set up in London and Paris by the U.S. Atomic Energy Commission. The offices are concerned exclusively with the applications of atomic energy for peaceful purposes and in particular with helping to implement the bilateral agreements the United States has made with other Governments. The scientists allotted to them will visit British and French atomic energy establishments respectively, reporting developments of interest to the United States. They will also be available to industrial firms, the public and Press for consultation on 'atoms for peace' problems. Dr. Edward L. Brady, a thirty-seven year old atomic scientist previously with the General Electric Company at the Knolls Atomic Power laboratory at Schenectady, N.Y., has taken up his duties as liaison officer in London. He worked on the war-time atom bomb project in the Metallurgical Laboratory and Oak Ridge National Laboratory and has specialized in corrosion studies, fuel element stability and the chemistry of reactor coolants. Dr. Brady is being assisted by Mr. William A. Burke of the U.S. State Department. Mr. Burke was formerly at the Berkeley Radiation Laboratory and Washington Headquarters. The liaison office is at the United States Embassy in London. Dr. Amasa S. Bishop, formerly of the Commission's Research Division, has been appointed to the Paris post. He has been in charge of the American programme for controlling thermonuclear energy for power purposes and is also a specialist in meson physics.

Exchange of Information on Controlled Thermonuclear Reactions

UNDER the agreement for co-operation in the civil uses of atomic energy between the Governments of the United Kingdom and the United States, an

exchange of classified and unclassified information on research in the field of controlled thermonuclear reactions has been agreed. A party of scientists from Harwell visited the United States in October 1956 to see and discuss work in this field, and a party of scientists from the United States made a return visit in the following month to Harwell and to the laboratories of Associated Electrical Industries, Ltd., where work is being done under contract for the Atomic Energy Authority. About ten British scientists will take part in a classified conference on the subject which has been organized by the United States Atomic Energy Commission in Berkeley, California, starting on February 20.

Atomic Age Studies at Columbia University

Columbia University has announced the creation of a Council for Atomic Age Studies, with the objective of making the University a centre for the study of problems facing society as a result of the development of atomic energy, problems which in many instances overlap a number of fields of activity and different branches of learning. Fields of study represented on the Council itself include physics, engineering, medicine, international relations, journalism, business, philosophy and law. Prof. I. I. Rabi, Higgins professor of physics, and Prof. P. C. Jessup, Hamilton Fish professor of international law and diplomacy, have been designated co-chairmen.

The Council will initiate, organize and supervise studies, drawing on the competence of many disciplines and activities of the University to examine some of the effects of the development of atomic energy on such diverse areas as industry, law, economics, foreign policy, international relations, agriculture, physical and mental health, domestic economy, city planning and community life. (The effects of such areas in turn on atomic development may also require study.) Possible studies include various issues in the international development of atomic power which involve research in technology, law, economics and foreign policy. Similarly, there is need to consider in joint studies the effect of new forms and sources of power on industry and agriculture, on physical and mental health, and on the domestic economy and the life of communities.

Botany at University College, London : Prof. W. H. Pearsall, F.R.S.

Prof. W. H. Pearsall, who attained the age of retirement last year, succeeded Sir Edward Salisbury as Quain professor of botany at University College, London, in 1944. Previously he had occupied the chair of botany at the University of Sheffield for seven years and prior to that had been lecturer in the University of Leeds. During his tenure of the Quain chair, the Botany Department shared in the general post-war expansion of science departments at University College, with its consequent problems of congestion. The bomb damage suffered by the College inevitably delayed the necessary expansion and Prof. Pearsall had to cope with the interim expedients while his successor will enjoy the benefits of the provision which Prof. Pearsall planned. Despite these and other University preoccupations, Prof. Pearsall found time to serve on a number of scientific bodies. He took a prominent part in the development of the Freshwater Biological Station at Windermere, especially in its early years; he was a very active member of the British Ecological Society, of which he became president and for some years effectively edited its *Journal*; also since 1947 he has edited the *Annals of Botany*. Prof. Pearsall has made important contributions to plant physiology and to the study of the ecology of freshwaters and moorlands. He was elected a Fellow of the Royal Society in 1940 and has twice served on its Council.

Dr. D. Lewis, F.R.S.

Dr. Dan Lewis has been appointed Quain professor of botany at University College, London, in succession to Prof. Pearsall. Dr. Lewis went to the John Innes Horticultural Institution when it was at Merton in 1935. Until 1948 he worked in the Pomology Department. At first he was concerned with the general breeding of fruits, but soon he concentrated his attention on the problem of incompatibility. In the course of this work he developed a combination of physiological and genetic techniques which brought a new understanding of gene action and of gene evolution. Splitting the incompatibility gene and comparing the frequencies of natural and induced mutation in pollen were two examples of his experimental skill. Later, Dr. Lewis has applied his own methods and his own point of view to the study of cytoplasmic heredity, heterosis, and breeding systems in flowering plants and fungi. In every direction he has shown a gift for extracting fundamental principles from practical problems. Dr. Lewis became head of the Genetics Department at the John Innes Institution in 1948 and was elected a Fellow of the Royal Society in 1954. His appointment as head of a university department, the sixth to be made from the staff of the John Innes Horticultural Institution in the past ten years, should prove stimulating and fruitful for both parties.

Biology at the Massachusetts Institute of Technology : Prof. I. W. Sizer

Prof. Irwin W. Sizer has been appointed head of the Department of Biology at the Massachusetts Institute of Technology. Prof. Sizer, who is well known for his studies of the fundamental properties and medical applications of enzymes, is at present studying the use of enzyme inhibitors as antibiotics and in chemotherapy. He is also doing research on the medical aspects of enzymes as related to skin grafting in the treatment of severe burns. Prof. Sizer has also studied extensively enzymes which are concerned with the clotting of blood, and others which bring about the oxidation and destruction of the toxic irritants of poison ivy. In addition, he has worked on the spectroscopy and biochemistry of collagen and has done research in connexion with the use of sheep gut, of which collagen is the principal constituent, for surgical sutures. A native of Bridgewater (Massachusetts), Prof. Sizer received his A.B. from Brown University in 1931 and his Ph.D. from Rutgers University in 1935. He went to the Massachusetts Institute of Technology in 1935 as lecturer in biology and public health, became an associate professor in 1942 and executive officer of the Department in 1954. He became acting head of the Department in 1955 and was appointed full professor in 1956.

Science at Unesco

Under the title "Ten Years of Science at Unesco", Prof. M. Florkin has contributed to the issue of

Impact for September 1956 an excellent review of the evolution of the programme of the Department of Natural Sciences and the achievements of the United Nations Educational, Scientific and Cultural Organization in the fields of international scientific co-operation, teaching and dissemination of science in the past decade. Besides the assistance given to international scientific organizations, such as the International Council of Scientific Unions, and the formation of the Council of International Organizations of Medical Sciences and the Union of International Engineering Organizations, Prof. Florkin emphasizes the importance of new forms of international scientific co-operation fostered by Unesco (despite the abandonment of the Institute of the Hylean Amazon through the failure to secure ratification of the Convention by the necessary five States), such as the Arid Zone project and the Humid Tropical Zone project. The former served as model when in 1955 an advisory committee on marine sciences was set up to consider methods of developing the scientific study of the ocean and of supplying information which would lead to increased use of marine resources. Although the European Centre for Nuclear Research is the most successful and best known of the international laboratories fostered by Unesco, the International Computation Centre in Rome was established earlier, though only five centres are so far participating. The establishment of an institute for the study of plants and animals under fully controlled conditions is still under consideration. Travelling exhibitions, a series of inventories of apparatus and materials for teaching science, to consist of eight volumes, and the publication of text-books and manuals on science-teaching are among the means adopted for furthering the dissemination and teaching of science, while an advisory committee on scientific research has met three times since April 1954, and Field Science Co-operation Offices cover Latin America, the Middle East, South and South-East Asia.

The Mathematical Association

THE annual general meeting of the Mathematical Association was held at King's College, London, on January 2 and 3, with the president, Prof. G. Temple, in the chair. In his presidential address, Prof. Temple spoke on the growth of mathematics and stressed the importance of the contacts which mathematics now has with engineering and technology. This address was followed by a discussion on "Mathematics and the Humanities". The opening speakers were Dr. Martin Johnson and Lady Jeffreys. Dr. Johnson spoke of the part mathematics plays in the cultural life of the community, and Lady Jeffreys analysed the time-tables of two schools to compare the proportion of time spent on scientific subjects with the time spent on 'arts' subjects. In the evening of the first day, Dr. E. R. Lapwood described how earthquake records provide us with knowledge of the deep interior of the Earth. On the following morning Mr. T. V. Davies spoke about the modifications which recent information on the distributions of wind velocity and temperature in the upper troposphere has brought about in the original concept of meridional cells. This was followed by a brief report on the work of the International Commission on Mathematical Instruction and a discussion on the serious shortage of teachers in mathematics. In the afternoon a discussion on comprehensive schools was opened by Miss M. G. Green and Mr. E. E. Godfrey. The meeting closed with a lecture by Mr. G. Macknelly on an amusing application of symbolic logic to the problem of overcrowding in the university library. A publishers' exhibition was open throughout the meeting.

The Palæontological Society of India

INTRODUCING the *Journal of the Palaeontological Society of India* (Inaugural Number. Pp. viii+230+xxxvi+37 plates. (Lucknow, 1956.) Rs. 30), M. R. Sahni, founder-president, describes the foundation in 1950 of the new Society and discusses its objects, which include the formation of a palæontological research centre, a library and a museum. Committees are to be formed to study such Indian problems as the Vindhyan system, the Pleistocene Siwaliks and fossil man in India, and ultimately it is hoped to extend the scope of the Society to South-East Asia and to hold meetings in other capitals. These enthusiastic plans for the future are coupled with a clear appreciation of past work in the subcontinent which is chronicled at length in the form of an annotated bibliography. The subjects of the thirty original papers include plants, foraminifera, brachiopods, vertebrates, prehistory and evolution. The half-tone illustrations are printed, sometimes on both sides of the page, on the same paper as the text; the reproduction is good.

World Directory of Crystallographers

THE International Union of Crystallography is preparing a World Directory of Crystallographers, containing the names and addresses of all practising crystallographers, including advanced graduate students. It is hoped to compile a preliminary list in time for the Fourth General Assembly to be held in Montreal during July 10–17. The secretaries of the national committees (*Acta Cryst.*, 8, 857; 1955) have been asked to prepare a list of crystallographers in their countries. Some scientists and technologists, however, who carry on crystallographic work (including X-ray, electron or neutron diffraction and microscopy or other techniques) are not members of scientific societies having a unique crystallographic interest, and might therefore be missed. Those who come into this category are asked to send their names and addresses to Dr. W. Parrish, Philips Laboratories, Irvington-on-Hudson, New York.

Indian National Scientific Documentation Centre

A FURTHER 16 per cent increase in the demand for its documentation services is recorded in the annual report of the Indian National Scientific Documentation Centre (Insdoc) for 1955–56, the total of 5,559 orders comprising requests for copies of 4,557 papers, translations of 570 scientific articles and compilation of 78 bibliographies. Publication of the semi-monthly "Insdoc List of Current Scientific Literature" continued, each issue listing 1,200 titles of scientific papers and also of the quarterly *Annals of Library Science*. Towards the end of the year closer contact was established with scientific institutions in South and South-East Asia.

Cameroons King's House

"THE King's Day: a Day in the Life of an African King", by Margaret Plass, is a pleasant little pamphlet issued by the Chicago Natural History Museum (pp. 29+9 plates; 35 cents) to illustrate the Cameroons King's House now on exhibition there. It

portrays the king getting up in the morning and finally going to bed, having spent the day in dealing with the necessary duties of his office. There are ten full-page illustrations, including a bead crown, drums, wine gourds, pipe bowls, etc. The whole is well put together and gives a good picture of native life from the point of view of a king.

The Trans-Atlantic Telephone Cable

A JOINT meeting of the Institution of Electrical Engineers, the American Institute of Electrical Engineers and the Engineering Institute of Canada was held on January 24, during which the lecture theatres of these three bodies in London, New York and Montreal were connected together by the trans-Atlantic telephone cable, which was opened for public service last September. At the beginning of the proceedings, the presidents of the American and Canadian bodies appointed Sir Gordon Radley, president of the Institution of Electrical Engineers, to act as chairman of the joint meeting. Thereafter, for about an hour, the authors of each of twelve papers spoke in turn over the cable, giving a brief account of the planning, design, construction and laying of the various sections of the cable. At the end of the symposium the clarity of transmission over the cable was demonstrated when identical recordings of music were played in London and New York. Switching from one source to the other gave an immediate comparison of quality between the locally produced music and its counterpart from across the Atlantic. Without the indicator provided in the lecture theatre in London, it would have required a very sensitive musical ear to determine the source of the music.

Nuclear Energy and the Mellon Institute

THE entry of the Mellon Institute into the field of the peaceful applications of nuclear energy is announced in a seven-page booklet recently issued by the Institute. A Department of Radiation Research is to be established, under the directorship of Dr. Robert H. Schuler, who was formerly a member of the staff of the Brookhaven National Laboratory. The facilities of the new Department are to include a 3-million volt Van de Graaff accelerator, laboratories for radiochemical and allied work, laboratories for general work, a radiation library, offices, and equipment for using radioactive cobalt and other radiation sources. The Department of Radiation Research will be the sixth department established by the Institute to aid the numerous comprehensive research programmes sponsored by industrial concerns or associations.

Spectral Types of Southern Stars

IN 1949 it was decided to re-classify the objective-prism spectra taken by the late W. B. Rimmer, and partly described in *Mem. Commonwealth Solar Obs.*, No. 2; 1930. This description is in accordance with the newer system developed by W. W. Morgan and his associates, an account of which appeared under the title "An Atlas of Stellar Spectra" (Univ. of Chicago Press, 1943). Dr. S. C. B. Gascoigne supervised Miss M. L. Woods in the conduct of this work, which was completed in 1951 but remained unpublished until Dr. W. Buscombe was able to take the responsibility of editing the data for publication (*Memoirs of the Commonwealth Observatory*, Mount Stromlo, Canberra; Memoir No. 12 (3, No. 2). Spectral Types of Bright Southern Stars. By Mary Lee Woods; May 1955). The Memoir deals with 520 bright stars and includes all the stars for which Rimmer's spectra are sufficiently clear, with the exception of a few composite spectra, and in addition to the data contained in nine pages of tabular matter, three pages are devoted to an introduction, procedure, notes on different types, absolute magnitudes, the catalogue, and acknowledgments.

Venezuelan Institute for Neurology and Brain Research

THE first (pilot) section of the Venezuelan Institute for Neurology and Brain Research (see *Nature*, 176, 1049; 1955) has now been completed and the Institute has issued an illustrated brochure which is available on application to the director, Dr. H. Fernandez-Moran, Instituto Venezolano de Neurologia e Investigaciones Cerebrales, Caracas, Venezuela. The brochure gives a plan and photographs of the Institute and indicates the work of the various departments. The use of the ultramicrotome and the production of diamond knives is described and a section deals with the application of nuclear magnetic resonance spectrometry to cell studies. Next March the Institute will be holding an international symposium on "The Fine Structure of the Nervous System" under the auspices of the International Society for Cell Biology.

Scientific Institutions in Latin America

A SECOND volume of "Scientific Institutions and Scientists in Latin America", dealing with Colombia, issued by the United Nations Educational, Scientific and Cultural Organization (Centro de Cooperacion Cientifica para America Latina, Montevideo. Instituciones Cientificas y Cientificos Latinoamericanos. Colombia. (20 Volumen.) Pp. ii+176. Montevideo, 1956), contains information, revised and brought up to date, on institutions and scientists, contained in Vol. 1, issued in 1949, as well as on some not formerly included. The arrangement is alphabetical for both institutions and scientists, and there is in addition a subject-index.

Scientific Research at the British Museum (Natural History)

THE British Museum (Natural History) has such an attraction for the general public that its main function as an institution for scientific research tends to be hidden. For this reason the production of a booklet describing some of the research which has been and is still being done at the Museum will be welcomed by many visitors as well as all natural history scholars ("Scientific Research at the Natural History Museum". Pp. vi+46. London: British Museum (Natural History), 1956. 2*s*. 6*d*.). The booklet describes the way in which the main research activities in various departments are organized, as well as specific investigations by individual sections or members of each department. The booklet is well written and well illustrated and should prove a valuable addition to the publications of the Museum. If a reprint is made, the cover of the journal might bear a closer relation to its contents than one which appears to be more appropriate for publications of the Science Museum.

Sarawak Museum, Borneo

DURING the past few years there has been news from time to time of the great vitality of the Sarawak

Museum under its director, Mr. Tom Harrisson. Field research in various directions has been undertaken, new buildings have been put up, and the *Journal* of the Museum has been revived. Two recent issues of the *Sarawak Museum Journal* (6 and 7, New Series) give some indication of the scope of its activities. They include historical matter, notably an account of some of the pioneers of development in Borneo, zoology, accounts of aboriginal customs, myths and archæology. A matter of some general interest is the occurrence of Chinese porcelain and other imported wares in the possession of aboriginal groups in the interior. This is the subject of an article by the director, and further light is thrown on it by the report of the excavation of two interesting burials of about a century ago by Mrs. Harrisson. In a time of rapid change, the *Journal* is performing a useful service in recording information which will soon be unobtainable, besides the results of exploration and research where much remains to be done.

University of London : Appointments

THE following appointments in the University of London have been announced: Dr. C. C. Butler, reader in physics, and Prof. A. W. Skempton, professor of soil mechanics, both of the Imperial College of Science and Technology, to the University chairs of physics and of civil engineering, respectively, tenable at that College; Dr. M. J. Blunt, senior lecturer in anatomy at St. Bartholomew's Hospital Medical College, to the University readership in anatomy tenable at that College.

The Physical Society Exhibition

THE Physical Society Exhibition of Scientific Instruments and Apparatus is to be held during March 25–28 in the Royal Horticultural Society's Old and New Halls, Westminster, London, S.W.1. The opening ceremony will be performed in the New Hall by Prof. P. M. S. Blackett, on March 25, at 11 a.m. Discourses will be given at 6.15 p.m. as follows: (March 25) "The International Geophysical Year", by Sir Harold Spencer Jones; (March 26) "The Supply and Distribution of Liquid Helium", by Dr. E. Mendoza; and (March 27) "On Recent Trends in Acoustics", by Prof. E. G. Richardson. Inquiries should be addressed to the Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

Gas Chromatography

A SYMPOSIUM on "Vapour Detectors for Gas Chromatography" will take place at the University of Oxford on May 3, at 11.15 a.m. The meeting is being organized, under the auspices of the Hydrocarbon Research Group of the Institute of Petroleum, by the Gas Chromatography Discussion Group. The following detectors will be described: β-ray ionization cells; the low pressure discharge tube; the gas density balance; and thermistor thermal conductivity cells. The proceedings will not be recorded or published. Application for tickets should be sent (before April 1) to Mr. D. H. Desty, Gas Chromatography Discussion Group, British Petroleum Co., Ltd., Research Station, Chertsey Road, Sunbury-on-Thames, Middlesex.

Announcements

DR. F. T. ROSSER has been appointed vice-president (administration) of the National Research Council of Canada. Dr. Rosser, who was formerly director of the Division of Administration, succeeds Dr. E. R. Birchard, who continues in his position of president of Canadian Patents and Development, Ltd.

AMONG the courses being given at Norwood Technical College is one of twelve lectures, held on Saturday mornings from 9.15 a.m. to 12.30 p.m., commencing on April 6, on "Semi-microchemical Methods". Application forms may be obtained from the Secretary, Norwood Technical College, Knight's Hill, London, S.E.27.

THE Society for Applied Bacteriology announces that during its summer conference, to be held in Leeds during July 2–5, a one-and-a-half day symposium will be presented on "The Formation and Germination of Bacterial Spores". Further details can be obtained from the secretary, G. Sykes, Boots Pure Drug Co., Ltd., Microbiology Division, Nottingham.

A DISCUSSION on the "Molecular Mechanism of Rate Processes in Solids" will be held by the Faraday Society in conjunction with the Koninklijke Nederlandse Chemische Vereniging at the Netherlands Royal Tropical Institute, Mauritskade, Amsterdam, during April 15–18. Inquiries should be addressed to the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

AN Electronics Exhibition, organized by the Radio and Telecommunications Group of the North Western Centre of the Institution of Electrical Engineers, is to be held in the College of Science and Technology, Manchester, during March 26–27. This Exhibition is intended to stimulate recruitment to the electrical engineering profession. Demonstrations of working electronic equipment will illustrate the type of work undertaken by those choosing electronic engineering as a career.

THE Photoelectric Spectrometry Group recently conducted a survey on the use of spectroscopic solvents in an effort to assist the manufacturers of solvents in determining a likely market and quantities in demand. A preliminary report compiled by Dr. H. Campbell has been published in Bulletin No. 9 (September 1956) of the Photoelectric Spectrometry Group (from the Hon. Secretary, 56 Arbury Road, Cambridge; 7*s.* net).

THE Italian Physical Society is organizing the third International Conference on Ionization Phenomena in Gases, to be held in the Fondazione G. Cini in Venice during June 11–15. The four general sections will discuss: fundamental processes in ionized gases; mechanism and properties of various types of discharges; nuclear reactions in discharges; and technical and instrumental questions. English will be the preferred language, and the proceedings will be published in the *Supplemento* of *Il Nuovo Cimento*. Those who wish to attend the Conference or require further information should write before March 15 to the general secretary of the Conference, Prof. Ugo Facchini, Laboratori CISE, Via Procaccini 1, Milan.

ERRATUM. In the review entitled "Story of the Atom Bomb" in *Nature* of February 2, it is stated (p. 223) that a permanent increase by a factor of 100 in the general level of ionizing radiation would result in "a world radiation dose to the whole population of more than 400 roentgens"; for "400 roentgens" read "300 roentgens".

THE SOUTH AUSTRALIAN MUSEUM

THE *Records of the South Australian Museum* (12 ; 1956) is an outstanding issue as it includes an illustrated record of the first hundred years, 1856–1956. The account is compiled by the present director, Mr. H. M. Hale, who has been on the staff since 1914 and is thus able to relate much of the story of this well-known Museum from personal knowledge.

The establishment of a natural history museum in South Australia was considered at a very early stage in the history of the State, and a Natural History Society formed in 1838 had for its object "the cultivation of the Science of Natural History in all its branches and more especially the Natural History of South Australia". Another potent influence at that time was the Adelaide Philosophical Society founded in 1853. Thus the usual pattern, so often seen in English towns, was set and the South Australian Institute was founded in 1856. The Institute comprised a library and a museum, and its first Government grant was the modest sum of £350. Specimens soon accumulated—chiefly geological and entomological—and meanwhile the search for accommodation was pursued with vigour. Eventually a site was procured, and the building was opened, though still incomplete, in 1861. Mr. F. G. Waterhouse was appointed as the first curator in 1859 at a minimum salary of £50 rising to a maximum of £200. Also, then as now, a very small purchase grant made it necessary for the Museum to depend on gifts rather than on grants. Lack of accommodation and financial support soon became apparent and the difficulties of the Board were those common to committees and directors of the present day.

By 1865 Waterhouse had become concerned about the limited exhibition space at his disposal, but it was not until 1873, after prolonged efforts to urge the Government to provide the necessary grants, that the foundations of the west wing extension were laid. It was, however, only in 1882 that the material was placed in the new west wing, the formal opening taking place in 1884.

In 1883 Dr. Wilhelm Haacke was appointed director, and the change in title of the chief official was accompanied by the renaming of the Institute with its present title of "The South Australian Museum". The mounting of expeditions was one of the major activities of the Museum in that period of its existence, and especial mention must be made of the skeletons of *Diprotodon* which were found in a water-course near the margin of Lake Callabonna.

It was not long after the occupation of the west wing that the grave disadvantage of having a public library, museum and art gallery in one building became apparent. In 1893 the red brick building which constitutes the north wing of the block was completed and formally opened early in 1895. Thus almost forty years after the founding of the South Australian Institute the Museum was for the first time housed in a building provided solely for that purpose ; although the museum, the art gallery and the public library continued to be associated under one board for a further forty-five years.

The next twenty years, 1895–1915, were a period of concentrated effort within the Museum. Expeditions were few and intensive curatorial work by members of the staff placed the now extensive collections in good order. Ever since the 'eighties research had been considered as one of the important activities of the South Australian Museum ; but in the period after the First World War the staff wrote an increasing number of original papers, particularly for the *Proceedings of the Royal Society of South Australia*, of which many were Fellows. This activity led to the publication of the *Records of the South Australian Museum*, containing papers by members of the staff.

The beginning of the period 1928–40 started with a long-term reorganization of the Museum and ended with the establishment of three new government departments—the library, museum and art gallery. Much surplus material was removed from exhibition and an impression of spaciousness was produced by eliminating some of the 'funeral black' cases. This re-organization was expedited by a visit of a delegation from the Carnegie Corporation of New York. During the years 1940–46 the Board was faced with the difficulties and responsibilities consequent on the Second World War. When Japan entered the War in 1941 a large part of the collection was removed as an air raid precaution to safer storage away from Adelaide. At first the objects were placed in wine cellars scattered in the Mount Lofty Ranges but these proved unsuitable, and after the bombing of Darwin in 1942 a disused railway tunnel provided a more efficient shelter. With a depleted staff this was no light task and much help was given by the honorary officers. The Army Education Service also called for assistance and during one year more than one hundred lectures and demonstrations were given in the Museum, in camps and in hospitals. In addition to these and other duties, the staff carried out much research on war-time problems. The last decade, 1946–56, marked the gradual return of the staff and the initiation of many experiments in exhibition and conservation. The majority of the cases were painted and a new feature was an exhibit concerning game-birds and details of the legislation passed to ensure that these birds were not exterminated. Miniature dioramas were also constructed.

The history concludes with a note concerning the future. It is rightly maintained that the South Australian Museum has outstanding collections and that the improvisations and makeshifts which have been practised for at least fifty years have reached a stage when drastic action is necessary. The conclusion is reached that there is no satisfactory alternative to the erection of a new building, preferably in a landscaped setting, planned to meet modern requirements. Spacious exhibition floors with no supporting pillars and with provision for smaller units by means of movable partitions allowing elasticity for display are rightly considered to be essential.

This is a moving story of a great museum related in simple language. It is an important contribution to museum literature not only on account of the elaborate details it relates but also as a record of a large museum and the trials and difficulties which arose and were overcome. It is a record of the acquisition and conservation, despite set-backs, of the present important collections of ethnological, zoological and mineralogical objects and is in many ways an epitome of the history of the museum movement in all parts of the world.

F. S. Wallis

USE OF VISUAL AIDS IN TEACHING SKILLED MANIPULATIVE TASKS

By Prof. M. D. VERNON

Department of Psychology, University of Reading

INCREASING interest has been aroused in recent years in the possibility of devising improved methods of teaching manipulative tasks of all levels of complexity. Often instructors are not readily available for teaching; or their skill in teaching, as apart from their ability to perform the tasks themselves, may be deficient. The current popularity of 'visual aids' in education—films, film-strips, television, etc.—has suggested that they might be of considerable assistance in the teaching of manipulative tasks. They could utilize standardized and efficient methods of instruction; and they could be employed on a large scale, and might obviate the necessity of highly skilled instructors. Indeed, it is claimed that, in the Services, films and film-strips have been found valuable for such instruction.

There has been a tendency to accept uncritically the efficacy of film instruction for teaching manipulative tasks. A recent inquiry by S. Laner[1], however, suggests that considerable caution is necessary in the use of films for this purpose. Laner investigated the effectiveness of film instruction in teaching people to perform three tasks: (1) repairing the sash-cord of a window; (2) assembling the trigger mechanism of a Bren gun; (3) constructing a complicated paper model. (The films used for tasks (1) and (2) were ordinary commercial films; that used for task (3) was a film specially prepared to give the clearest possible demonstration of the method of construction.) The ability of learners to perform these tasks after film instruction was studied individually, and was compared with the ability of other learners to perform the tasks after instruction, in (1) and (3) by film-strip and verbal commentary, in (2) by a written text accompanied by diagrams. The intelligence and 'spatial ability' of the learners varied over a wide range, but was similar on the average for the experimental and control groups.

In general, it was found that the performance of those taught by films was not superior to that of those taught by the other methods. It did not seem that the greater detail, the continuity and the movement of the film had any advantage, even for the understanding of a moving piece of machinery such as the trigger mechanism of the Bren gun. Indeed, the films possessed certain marked disadvantages. They were liable to pass too quickly over the more difficult parts of the task, and the learners had insufficient time for these stages, or were unable to see them clearly enough. They felt that they were being 'pulled along' by the film displays, and could not control their learning processes. If they failed to grasp clearly the essential stages, their subsequent performance of the task tended to break down.

It transpired that the learners did not acquire passively a train of visual images of the display. Instead, they perceived it actively, and constructed in their minds a kind of plan, described as 'getting the general idea' of the task. This plan was formulated verbally, though accompanied by some visualization, but not by the recall of imagery exactly reproducing what had been shown. The coherence and clarity of the sound commentary were thus of the utmost importance to the formation of the plan. In particular, it could describe the relationships between parts of the material and stages of the task which could not be displayed visually. In the third experiment, one group of learners which was shown the film without any verbal commentary made a much poorer performance than the group which heard the commentary.

On the other hand, the form of the visual display was of comparatively minor importance provided that it could be employed in visualizing effectively some of the steps of the task. Once the 'general idea' had been grasped and the plan formed, the learner could utilize it to perform the task, this performance being more in the nature of an active reconstruction than a mere copying of what was shown in the display. This is not to claim that there is no necessity for employing any form of visual display in the instruction of skilled manipulative tasks. But it need not be a detailed copy of the manipulation; it must rather afford the learner the kind of information which he can employ most readily in formulating his plan of action. For this purpose, diagrammatic material may often be more effective than pictorial material.

This work was carried out in the Department of Psychology at the University of Reading, by means of a grant from the Nuffield Trustees, to whom grateful acknowledgment is made.

[1] Laner, S., *Quart. J. Exp. Psychol.*, **6**, 95 (1954); *Brit. J. Psychol.*, **44**, 280 (1955); "An Experimental Study of Pictorial Methods of Instruction", unpublished Ph.D. thesis, University of Reading.

THE BRITISH FLORA DURING 1956

THE progress made in increasing knowledge of the flora of the British Isles during 1956 has been equal to that of recent years[1]. In spite of much inclement weather hampering field work, at least one species of outstanding interest has been added to our list, while important extensions of range have been reported for some of our rarest species. Very satisfying progress has been made in recording general distribution and in the study of variation, while it is evident that some of the new work initiated during the year offers considerable promise for the future. All these aspects were represented at the annual exhibition meeting of the Botanical Society of the British Isles, arranged in the lecture room of the British Museum (Natural History) on November 24. The meeting was attended by about 350 members and guests, and a full account of the exhibits will appear in the *Proceedings* of the Society.

The most important addition to the British flora is *Hypericum canadense* L., which has been found by Prof. D. A. Webb in boggy pools and channels by Lough Mask in western Mayo and western Galway. It was exhibited by D. McClintock. This species has a wide range in eastern North America and must be added to the small group of plants which comprise the 'North American element' in our flora, and are all associated with lakes or their vicinity. *H. canadense* has been found growing recently in France under very similar conditions[2], and while its occurrence there in a limited area as far east as Haute-Saône is puzzling, the discovery in Ireland adds support to the suggestion that in France it is a relict species.

The Committee for the Study of the Scottish Flora exhibited important recent discoveries. *Koenigia islandica*, known previously only from Skye, whence it was first reported in 1950, was found this year in Mull by R. W. M. Corner during an expedition of the Edinburgh University Biological Society. E. A. Blake found two colonies of *Saxifraga cernua* on limestone rocks at 3,000 ft. on the Ben Nevis range; it was known previously only from Ben Lawers and a hill adjoining Glencoe. With it in the new place grows the almost equally rare *S. caespitosa*, and also *S. rivularis* and other scarce plants of high altitudes. *Carex buxbaumii*, which is regarded as extinct on Lough Neagh, and recently known only from near Arisaig, was shown from a lochan in east Inverness, where it was found by D. S. Kettle in 1955. Miss M. McCallum Webster also exhibited plants from new Scotch localities, including *Carex norvegica* from Ben Lawers.

Another important extension of range is made by the discovery of *Cephalanthera rubra*, one of Britain's rarest orchids, in the Chilterns in Buckinghamshire. A colony with eleven plants in flower, and sixty-four non-flowering, was found in July, and photographs of some of the plants were shown by R. S. R. Fitter. He stated that none of the 1956 flowers set seed. Until this year the species was only certainly known in Britain from the Cotswolds, and Dr. G. W. T. H. Fleming exhibited a specimen with swollen ovaries, claimed as the only known instance of the fertilization of this orchid in Britain. It is known to have exceptional powers of vegetative growth and is a facultative saprophyte, so it could persist for long periods without regeneration from seed. This may explain the erratic appearance of flowers in the Cotswolds and why the strong Chilterns colony, which must have been there for many years, has been so long overlooked. Miss A. P. Conolly and Miss P. M. Smith (Leicester) showed specimens of *Cicendia filiformis* from near Nevin in North Wales. They found it there in August 1956 and, as was evident from the map of the distribution of this species which they exhibited, the new locality is more than sixty miles north of the places from which it was previously known in Wales.

The major effort to record the detailed distribution of vascular plants in Britain being made by the Distribution-Maps Scheme of the Society has shown most satisfactory progress during the year. With the support of nearly 3,000 observers, about half a million records have now been received, and some 250,000 of these are already transferred to punched cards and available for the mechanical production of maps. The exhibit provided by the Cambridge office of the Scheme included a map showing the minimum number of records received for each of the 10-km. squares of the National Grid extended to cover the whole of the British Isles. For England and Wales, only 13 per cent of the squares have less than fifty records (some have totals ranging up to more than 800), while for Scotland and Ireland about 30 and 50 per cent of the squares are similarly heavily under-recorded. Taking 200–250 species as the minimum target, it is expected that the 1957 field-work should bring almost all the squares up to a reasonable standard. Dr. J. G. Hawkes (Birmingham) and R. C. Readett provided an exhibit to show the methods being used in the preparation of the Warwickshire county Flora. For each of the 2,500 one-kilometre squares of the National Grid in the county, species are recorded using habitat symbols. Sample maps plotted with the data so far available indicated how distribution could be compared with the known geological structure of the county, and habitat analyses showed that although many species overlap in habitat range, their preferences do not necessarily coincide, while some have a wider range of tolerance than others. An example of the thorough revision of the distribution of a single species throughout Britain was provided by E. W. Groves (British Museum (Natural History)), who showed a map with the known records of *Hippophae rhamnoides*, for which it is important to distinguish native habitats from those where it has been introduced by human agency.

One of the most promising lines for providing sound data for the interpretation of present distribution patterns is information about the occurrences of sub-fossil remains. Miss A. P. Conolly (Leicester) exhibited maps showing the present distribution and records from Full-glacial and Late-glacial deposits for *Betula nana*, *Oxyria digyna*, *Polygonum viviparum*, *Salix herbacea* and *S. reticulata* in the British Isles, together with some of the specimens on which the records were based. Dr. F. Rose (Bedford College) exhibited specimens from the Pas de Calais, to direct attention to some of the differences between the flora of Kent and that of the opposite area of France. A. J. Carpenter, P. J. Grubb and D. A. Guymer (Cambridge) showed specimens they had collected from Jugoslavia to show such British arctic-alpines as *Moneses uniflora* and *Oxytropis campestris* (ssp. *dinarica*) as they occur at the southern end of their range.

The progress made during the year in the interpretation of variation within species, or small groups of species, was illustrated by several exhibits. P. W. Ball (Leicester) showed that British species of *Salicornia* could be divided into two groups based on chromosome counts: the tetraploid species ($2n = 36$) are annuals growing in the lower regions of salt marshes, and include *S. dolichostachya*; the diploids ($2n = 18$) include *S. perennis*, *S. disarticulata*, *S. prostrata*, *S. ramosissima* (*A* and *B*), *S. europaea* (of Wilmott) and *S. gracillima*. C. Jeffrey (Cambridge) is working on *Bromus mollis* and *B. ferronei*, and exhibited a statistical comparison of spikelet size, florets per spikelet and lemma-length based on plants in natural habitats, on herbarium specimens and on plants grown from seed. A. C. Jermy (Leicester) showed material of *Carex*, section *Acutae*, which brought out an interesting ecological distinction between the much-confused *Carex juncella* and *C. nigra* forma *subcaespitosa*. The former produces its large tussocks on the edges of streams in habitats with good water circulation, the latter grows in marginal fen laggs. N. M. Pritchard (Oxford) exhibited evidence that *Gentianella septentrionalis* may cover two separate taxa. Druce's apparent type is that found on the west coast of northern Scotland, the other is characteristic of the eastern side. P. J. Field (Cambridge) showed *Rumex conglomeratus* and *R. sanguineus*; G. Halliday (Cambridge), *Minuartia verna* and *Antennaria dioica* var. *hyperborea*; B. M. G. Jones (Leicester), *Cardaminopsis petraea*; I. H. McNaughton (Oxford), British species of *Papaver* and hybrids; B. T. Styles (Oxford), the variation in segregates of *Polygonum aviculare*; and Prof. T. G. Tutin (Leicester), variation in *Poa annua*.

Several current approaches to the study of variation were well shown in the fine exhibit provided by

Prof. and Mrs. J. Heslop-Harrison (Belfast). Ecological variation was illustrated by *Dactylorchis incarnata*, in which the subspecies are of the nature of ecotypes, while in *D. fuchsii* the subspecies are scattered on the western side of the British Isles and illustrate geographical variation. The difference in appearance between fertile seeds and, as an example, the infertile 'seed' of *D. fuchsii* × *D. purpurella*, was demonstrated with microscopes. A useful experimental confirmation of the identification of a hybrid from its morphological characteristics was exhibited by P. M. Benoit. In his garden he crossed *Stellaria media* with *S. neglecta*, using the former as the female parent, and was able to grow four plants to the flowering stage from seed thus obtained. These plants were similar to, though not identical with, wild plants he found at Arthog, Merioneth. The hybrid is highly sterile. R. A. Graham (Kew) exhibited *Mentha* × *maximilianae* (*M. aquatica* × *rotundifolia*), which has recently been detected in Cornwall and elsewhere. Dr. C. P. Petch and E. L. Swann showed *Carex* × *schmidtiana* Junge (*C. pseudocyperus* × *C. rostrata*), which has recently been found near Hockham, west Norfolk[3].

The exhibit provided by the British Museum (Natural History) included specimens of *Bromus benekenii* (Lange) Trimen from Britain. This grass is widespread on limestone, particularly in the Wye Valley and Yorkshire, and after much argument was dismissed by British botanists years ago as not worth separating from *B. ramosus*, and hence is not mentioned in recent British Floras[4–7]. Elsewhere it is regarded as a good species[8] and its claims deserve thorough investigation. The Museum also showed *Festuca rubra* var. *arenaria* × *Vulpia membranacea* from Dawlish Warren, gathered this summer by Mr. and Mrs. P. Hall. The hybrid involving this variety of *F. rubra* is claimed as new to Britain and to Europe. From Swanscombe Wood, west Kent, was shown *Lathyrus heterophyllus* var. *unijugus* Koch, which was previously overlooked as a broad-leaved form of *L. sylvestris*[9], of which the usual narrow-leaved form grows there in great abundance. The status of these two plants requires further study. The British Museum (Natural History) also exhibited part of its magnificent autograph collection showing the writing of John Ray, William Curtis, Sir Joseph Banks and other well-known botanists.

The spread of aliens continues to be one of the most important factors in changing the British flora, and *Veronica filiformis* is one of the species which is rapidly becoming locally abundant in natural habitats in many districts. It was the subject of an exhibit prepared by E. B. Bangerter and D. H. Kent, who showed how this native of the Crimea, Caucasus and Asia Minor, introduced into British gardens early in the nineteenth century, had dramatically increased since it was first recorded as an escape in 1927. The aquatic *Lagarosiphon major* owes its spread to its use by aquarists as an aerator and has been recorded this year choking ponds in four new places—in Jersey, Alderney, and Whipp's Cross and Maldon in Essex. Its present distribution was illustrated by D. McClintock, who also showed *Aremonia agrimonioides*, which was first noticed in Scotland a century ago, and has been seen this year in four wild localities in that country.

Techniques continue to improve, and perhaps the most important advance demonstrated this year was that of three-dimensional colour photography as applied to plants by L. C. and S. T. Jermyn. This was shown by means of a hand-viewer at the exhibition meeting and by projection on a large screen at the conversazione which followed. Their first public demonstration of this was at the South London Botanical Institute in 1955; but this year they have improved their technique and are now able to project enlargements of very small organs on the screen. It is evident that for scientific work this represents a great advance on ordinary colour photography. The value of a method of preserving plants indefinitely in a moist state is self-evident, and Dr. H. J. M. Bowen (Harwell) has been experimenting with the use of gamma rays to kill moulds and inactivate enzymes to this end. His exhibit showed that doses exceeding one megarep prevented decomposition and the growth of moulds, but unfortunately they dry the material and make it brittle and change the colour. D. H. and Miss G. W. Dalby showed photographs and various methods of drawing, comparing their merits for different purposes as used for botanical illustrations.

D. H. Allen directed attention to a paragraph discussing the variability of *Linaria vulgaris* in G. C. Druce's "Flora of Berkshire", 1897, which is a clear statement of the principles of introgressive hybridization[10]. This appeared some thirty years earlier than the publication usually cited as the first statement of introgression. Mrs. H. N. Clokie (Oxford) exhibited the manuscript of Dillenius's journey into Wales and some of the specimens he collected on his only holiday during the period 1721–28 when he was living with William Sherard.

Dr. V. H. Heywood (Liverpool) and Dr. S. M. Walters (Cambridge) exhibited sample printed pages and other explanatory material of a proposed "Flora of Europe", which is being planned by a committee of six British botanists with the collaboration of leading botanists from other European countries. There can be no doubt that by summarizing information now available only by consulting some thirty separate Floras and innumerable smaller publications, written in more than a dozen different languages, many aspects of the study of European plants would be greatly facilitated. If such a work can be produced in three or four convenient volumes, in the course of ten or twelve years as planned, the editors will render a great service to botany. One of the ways in which younger students are being encouraged to take a wider view in field studies was illustrated by the exhibit prepared by the Junior Activities Committee of the Society as a record of their visit to Obergurgl in the Tyrol during the summer. With the assistance of Prof. H. Gams, a very large number of interesting plants was seen, and the high standard of the herbarium specimens, photographs and sketches shown reflected great credit on the work of these young botanists. During the afternoon, coloured slides of plants taken during this Junior Meeting were shown in another room. J. E. Lousley

[1] Lousley, J. E., *Nature*, **177**, 18 (1956).
[2] Bouchard, J., *Bull. Soc. Bot. France*, **101**, 351 (1954).
[3] Petch, C. P., and Swann, E. L., *Proc. Bot. Soc. Brit. Isles*, **2**, 1 (1956).
[4] Boswell, J. T., Rep. Bot. Exch. Club for 1876, 38 (1878).
[5] Trimen, H., Rep. Bot. Exch. Club for 1877–78, 20 (1879).
[6] Trimen, H., Rep. Bot. Exch. Club, 1, 38 (1880).
[7] Trimen, H., Rep. Watson Bot. Exch. Club, 2, 28 (1905).
[8] Hylander, N., *Nordisk Kärlväxtflora*, **1**, 350 (1953).
[9] Kent, D. H., and Lousley, J. E., "A Hand List of the Plants of the London Area", 70 (1952).
[10] Druce, G. C., "The Flora of Berkshire", 370 (1897).

RADIO WAVE PROPAGATION

INTERNATIONAL COLLOQUIUM IN PARIS

A COLLOQUIUM was held in Paris during September 17–21, at which various aspects of radio wave propagation were discussed. The proceedings were organized by the French National Committee of the International Scientific Radio Union and the Société des Radioélectriciens. The time chosen was shortly after the eighth Reunion of the International Radio Consultative Committee in Warsaw, as a result of which a number of delegates from foreign countries attended who might not otherwise have been able to do so: there were in fact representatives of more than twenty countries present. The topics discussed fell broadly under the three headings of tropospheric propagation, ionospheric propagation and general theoretical problems.

Tropospheric Propagation

In view of the current widespread interest in the possible uses of ultra-high-frequency radiation for transmission to points far beyond the horizon, it was not surprising that much of the discussion in the sessions devoted to tropospheric propagation should be concerned with the physical processes involved in such transmission. Over the past few years several theories advanced to explain the phenomenon have been debated at length. For most of this time it has been held by many workers that the cause of long-distance tropospheric fields is scattering produced by fluctuations of refractive index due to turbulence in the lower atmosphere. A less widely held view is that advocated by T. J. Carroll: it is based on the normal mode theory applied to an atmosphere in which the refractive index decreases monotonically from its value at the surface of the earth to unity at some specified height, above which it is maintained at unity: the mathematical rigour of this theory has, however, been seriously questioned.

While recognizing the powerful stimulus to research and practical applications provided by the turbulence theory, some speakers at Paris were of the opinion that a new attack on the problem was becoming desirable. The various forms of the theory proposed by E. C. S. Megaw, by H. G. Booker and W. E. Gordon and by F. Villars and V. F. Weisskopf all postulate isotropic turbulence, and it is generally realized that this must be far from true. Soundings of the refractive index of the troposphere made by centimetre-wave refractometers, for example, provide evidence of marked horizontal stratification which is nearly always present in some height interval. Modifications of the turbulence theory to allow for anisotropy have been proposed, but these, it is felt, do not meet the full needs of the problem: as a consequence there is a trend towards explaining long-distance fields primarily in terms of partial reflexion and scattering from one or more layers in which there is a significant change in the gradient of refractive index with height from that occurring in neighbouring regions of the atmosphere above and below, and which may present a rough, or at times broken, surface to the incident radiation. This point of view was strongly expressed at the colloquium by L. J. Anderson. It is evident that much more work, both theoretical and experimental, remains to be done before a really satisfactory explanation of long-distance tropospheric fields is obtained.

J. B. Wiesner presented a general account of the principles underlying the design of tropospheric-scatter links for communication purposes. He directed attention to the fact that the propagation mechanism is not the only factor determining the choice of the optimum frequency for a given link; that is, within the range 400–5,000 Mc./s., which is generally regarded as being the band in which the most useful applications of tropospheric scattering can be made. Consideration must also be given to the power available for transmission, the sensitivity of receivers, and the feasibility of building the size of aerial which may be required; for if wide-band information is to be transmitted, highly directive aerials are essential. It thus appears that, for links 300–400 km. in length, the optimum frequency is somewhere in the region of 1,000 Mc./s.; but there is an advantage in using lower frequencies, of the order of 400–500 Mc./s., for appreciably longer links. The economics of the problem is also of considerable importance, and this aspect was discussed by P. Clavier.

In a description of work carried out at the Lincoln Laboratory of the Massachusetts Institute of Technology, J. H. Chisholm gave details of investigations of the angular distribution of tropospherically scattered radiation, and went on to consider the communication capacity of scatter links; he emphasized the importance of multipath propagation on this capacity and the use of highly directive aerials for minimizing such effects. Other work at the Lincoln Laboratory, dealing with the practical aspects of the design of long-range communication systems, was described by W. E. Morrow: the improvement in performance to be obtained by the use of space-diversity reception on scatter links was pointed out, and a demonstration was given showing the advantages of single-sideband amplitude modulation over frequency modulation for the reception of weak signals.

Much effort has been devoted at the U.S. National Bureau of Standards to the study of the characteristics of the troposphere by radio means; and various features of this work were outlined by J. W. Herbstreit. A great quantity of information has been collected concerning the variations of field strength with time and distance from the transmitter at frequencies in the range 100–1,000 Mc./s.; and this has been used to derive a model (statistical in nature) of conditions in the troposphere on the basis of the theory of turbulent scattering. Discussion on this topic at the colloquium was very lively, and the opinion was expressed by a number of speakers that it was perhaps unwise to apply the model for conditions—whether of climate or frequency—different from those for which the model had been derived. Other investigations at the National Bureau of Standards, described by B. R. Bean, have been concerned with the relationship between climatology and the value of the refractive index at the surface of the ground, which is correlated with transmission loss. The same speaker also gave an account of gaseous absorption of microwaves in the atmosphere in relation to tropospheric scatter systems.

The centimetre-wave refractometer has been used extensively in the past few years, particularly in the United States, for the investigation of refractive index variations in the troposphere. The results of such investigations were presented by C. M. Crain, who discussed the manner in which the refractive index varied in and around various types of cloud,

fronts and other atmospheric disturbances. The application of measurements made by means of refractometers to studies of radio wave propagation were also considered. Correlation of a more general nature between propagation characteristics and meteorological data obtained from routine radio-sonde observations was the subject of a paper by F. du Castel.

Other papers in the tropospheric propagation section of the colloquium were concerned with: the comparison of the amplitude and phase fluctuations associated with scatter transmissions (H. Bremmer), propagation experiments at short distances (P. Chavance), the effect of rapidly changing air-masses on tropospheric propagation (P. Misme), and optimum aerial apertures for scatter links (W. C. Hoffman).

Ionospheric Propagation

In the ionospheric section, the basic theory of reflexion of radio waves from the ionosphere was dealt with by P. Poincelot, and also by J. R. Wait, who considered mainly the problem of the propagation of atmospherics at oblique incidence and the interpretation of their waveforms. D. Lepechinsky made a contribution on the practical application of the Appleton–Hartree magneto-ionic theory: he discussed the importance of the influence of the Earth's magnetic field and the electron-collision frequency on the form of $h'f$ records.

The general problem of oblique-incidence propagation was the subject of much discussion, and W. Dieminger described the results obtained with variable-frequency pulse transmissions over a path of 1,300 km. Agreement between observations over this path and the results which would have been expected from data obtained by ionospheric soundings at vertical incidence was good except when the oblique $p'f$ traces showed an unexplained extension of the normal 'nose'. Measurements of short-wave field strengths and atmospheric noise made on ships sailing from Denmark to Greenland were described by C. Ungstrup; these experiments give direct confirmation of the abnormally high absorption of radio waves which occurs over an arc roughly coincident with the auroral zone. B. Beckmann directed attention to the use of commercial transmitters for making routine 'back-scatter' measurements which can help in the assessment of propagation conditions. Detailed studies of the timing signals from standard-frequency stations in the high-frequency band wave were described by J. Bouchard, who has used these signals to investigate modes of propagation; and also by Mme. Stoyko, who made use of them in the derivation of an empirical expression for the time of propagation as a function of distance which is correct to 0·1 millisecond.

A survey of the various problems which are encountered in the preparation of ionospheric forecasts for operational use was given by K. Rawer. The particular problem of forecasting vertical-incidence critical frequencies was discussed by C. M. Minnis, who proposed a monthly ionospheric index of solar activity which would reduce errors in forecasting to 60 per cent of the error incurred using an index based on sunspot numbers. In a contribution on the difficult question of forecasting the occurrence of ionospheric storms, P. Simon described how a distinction could be made between active and non-active sunspots by observations of the characteristics of the emitted radio noise.

The nature of the ionospheric mechanism by which very high frequency signals may be transmitted over distances of 1,000–2,000 km. was considered by J. A. Saxton. It seems likely that such signals are predominantly propagated by reflexion from trails of meteoric ionization during the night, but that during the day there is also an important contribution which depends upon fluctuations of electron density produced by turbulence in the lower E-region. The part played by meteoric ionization in radio wave propagation was also discussed by V. R. Eshleman, who pointed out that the factors which control the duration of a radio echo from a meteor trail include the wave-length, the electron line density in the trail, the rate of diffusion of the trail, and the geometry of the transmission path. As the path-length is increased, the average echo duration first increases to a maximum and then decreases.

There were a number of papers dealing with the propagation of very low frequency radiation including atmospherics. One of these, by F. Horner, was concerned with the possible dependence of the ionospheric transmission of very long waves on the direction of the path; and it appears probable that the polarization of the received signal does in fact depend on the horizontal direction of the path relative to the Earth's magnetic field. Papers were introduced by H. E. Dinger and R. Rivault on 'whistling atmospherics'—audio-frequency electromagnetic disturbances which are believed to have been propagated through the outer regions of the ionosphere—and discussions on this subject concentrated on the more complex and unusual types for which no theoretical explanations have as yet been advanced. F. W. Chapman also described work on audio-frequency radio waves, in the range 40 c./s. to 16 kc./s., and showed how, from an examination of the way the waveform and spectrum vary with distance of propagation, information may be obtained on the attenuation and velocity of these waves. E. T. Pierce showed that the waveforms of atmospherics received in England from sources in south-easterly directions are different from those originating at similar distances to the south-west.

Although the colloquium was mainly concerned with wave propagation, several speakers discussed problems of ionospheric physics. W. Pfister referred to recent rocket experiments which may be interpreted as confirming the existence of an irregular structure superimposed on the normal horizontal stratification in the E-region. A new graphical method of determining the vertical electron density distribution was outlined by W. Becker; this method allows for the Earth's magnetic field, and is designed primarily to deal with parabolic, cosine and Epstein distributions. E-region wind measurements made by E. Harnischmacher indicate a mean day-time velocity of 80 metres per second, and a diurnal clockwise rotation in direction of 30 degrees per hour. Results of work on the self-demodulation of radio waves on frequencies near the gyro-frequency were presented by M. Cutolo; and L. Goldstein described laboratory experiments on the simulation of ionospheric interaction phenomena under controlled conditions in discharge tubes.

General Theoretical Problems

Whether or not the Sommerfeld surface wave actually exists has been a topic for argument for many years, and it appears from the discussions at

Paris, which were stimulated by papers by A. Banos and G. Goubau, that no completely satisfactory answer to the problem has yet been reached. Also, in the general theoretical section of the colloquium there was extensive consideration of diffraction problems, a leading part being played by V. A. Fock, who presented a comprehensive paper dealing with the application of complex integrals to these problems.

A treatment of the scattering of high-frequency radiation by dielectric spheres was given by D. S. Saxon and Z. Sekera. It would seem that, while satisfactory theories exist for scattering processes when the wave-length is short compared with the scale of the inhomogeneities of the scattering medium, they are not valid at longer wave-lengths.

A matter of considerable importance in propagation studies is the reflexion of radio waves at rough surfaces. Various aspects of this subject were discussed by W. S. Ament, who gave quantitative results for surfaces conforming to certain simple models; and also by V. Twersky, who presented a generalized theory—though here again only simplified models are amenable to numerical treatment.

Current interest in long-wave transmission has been stimulated by recent theoretical work on the problem, notably that by K. G. Budden in which the space between the Earth and the ionosphere is treated as a wave-guide. It is hoped that new experimental work will help to resolve some of the difficulties in the theory which still exist. In this connexion the study of atmospherics is important, and it was interesting to hear a report in Paris by J. Aarons that measurements have now been made down to frequencies as low as 0·5 cycles per second, to supplement those which have been made for a number of years at higher frequencies.

It is proposed that the papers presented at the colloquium shall be published in a special number of *L'Onde Electrique* which will appear in the spring of 1957.

PHYSIOLOGY OF THE PRE-WEANING PERIOD

A CONFERENCE, in commemoration of E. Babák, was held by the Czechoslovak Academy of Sciences at Liblice, near Prague, during November 14–17, 1956. The subject of the conference was "Problems of the Physiology of the Pre-weaning Period in Man and other Mammals". Countries represented included the German Democratic Republic, Great Britain, Hungary, Rumania, the United States, U.S.S.R. and Yugoslavia.

A central topic was the development of thermo-regulation, on which extensive researches are being carried out in Prague, at the Institute of Physiology of the Academy of Sciences and at the Charles University. P. Hahn, J. Křeček, J. Křečkova and J. Martínek (Prague) contributed papers on the development of thermo-regulatory mechanisms in the rat, and on adaptation to cold and warm environments in infant rats. Other papers in this field included those of S. A. Barnett and B. M. Manly (Glasgow) on the effects of low environmental temperatures on young mice; K. W. Cross (London) on the reaction of the human new-born to lack of oxygen; A. Holub and others (Brno) on the development of thermo-regulation in piglets; and A. McLaren and D. Michie (London) on the effects of low and high temperatures on growth and variability in mice.

Other aspects of homeostasis were dealt with by J. Cort (Prague), who described work on the renal tubular excretion of acids in the human new-born; and Gertrude Falk (Washington), who discussed endocrine factors in the post-natal development of water diuresis. In addition, M. Hašek (Prague) gave an account of his important work on the adaptation of homeotherms to foreign antigens during early ontogeny.

Another major theme was the development of the nervous system. P. K. Anochin (Moscow) described an extensive series of researches on the relationship between functional maturation in the nervous system and the appearance of innate responses. I. A. Arshavsky (Moscow) gave a paper on the nervous system in the development of gastro-intestinal and circulatory function. K. Čapek and J. Jelinek described experiments on the external stimuli required to establish reflex micturition in puppies. P. Jílek and others discussed the development of normal brain function. J. Lát described researches in which individual variation in food choice in rats was found to be related to metabolic differences. J. L. Malcolm (London) reported on the pattern of response of motor neurons of the spinal cord in kittens, and the relationship between anatomical and functional development. A. D. Slonim (Leningrad) described a study of innate alimentary reflexes during ontogeny.

Visits were made to research institutes and medical centres in Prague. It was provisionally decided to hold a similar conference, again in Prague, in three or four years time.

S. A. Barnett

FATIGUE IN METALS

IN the hundred years since the term 'fatigue' was first introduced to define a certain type of unexplained service failure, a great deal of empirical knowledge has been accumulated, but there is still much to learn regarding the fundamentals of the processes involved. The Institution of Metallurgists has published a series of five papers*, presented as lectures during 1955, which together summarize, possibly better than has been done before, what is known and what is not known about this obscure phenomenon.

Dr. J. Holden deals with the fundamental considerations so far as they are known in a condensed but clear manner. It has been realized for a long time that fatigue depends greatly on the nature of the surface of the part under consideration, and Mr. G. Forrest is concerned to summarize the effect of notches and surface finishes, such, for example, as nitriding, shot-blasting, decarburization, etc., on the resistance to fatigue, and concludes that "the only general conclusion which can be reached is that the behaviour of materials with respect to notches and surface finishes is so complicated and related to so many variables that we are still a long way from being able to estimate the strength of complicated engineering components from fatigue tests on normal laboratory specimens".

* The Fatigue of Metals: Lectures delivered at the Institution's Refresher Course 1955. Pp. 148+16 tables. (London: Institution of Metallurgists, 1956.) 25*s*.

As an example of the practical aspects of fatigue and its investigation, Dr. P. B. Walker concerns himself with the structural aspects of aircraft fatigue, describing, incidentally, investigations carried out on large, and sometimes very large, specimens. That simultaneous action of corrosion and fatigue may lead to failure under stresses which normally would be borne without danger is well known, and Dr. R. B. Waterhouse discusses the theory and practice of corrosion fatigue, and the effect, sometimes large, of fretting. He concludes that "corrosion and fretting have a far greater influence on the fatigue strength than merely the production of pits in the surface which act as stress raisers", and again our ignorance rather than our knowledge of the phenomena involved appears to predominate.

Finally, Mr. P. H. Frith discusses the effect of temperature on fatigue properties over the range from liquid air temperatures to 870° C. An enormous mass of material has been tabulated, and the engineer-designer concerned with fatigue strength cannot but be grateful for the work involved.

Without pretending to be a comprehensive treatment of the subject, these lectures provide the engineer with a mass of detailed information, much of which is not readily accessible elsewhere in a condensed but easily assimilable form.

F. C. THOMPSON

ASTRONOMY AT THE CAPE OF GOOD HOPE

REPORT FOR 1955

THE Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for 1955* appears under seven headings, and in the first of these, "Buildings and Grounds", reference is made to their fairly good general conditions at the time of the Report. As a result of the extensive programme of works and repairs carried out during the past few years, relatively little maintenance had to be done in 1955. The work of ten instruments—including subsidiary equipment—is described under "Instruments"; the usual programme mentioned in previous Reports has been carried out, although the tower telescope was not used during 1955 owing to its ancient and rather unsteady mounting. This will receive a complete overhaul and the 6-in. lens will be repolished before the instrument is used again for serious work. The mirrors and tube for the 18-in. reflector were received from Messrs. Cox, Hargreaves and Thomson during 1955 and have been mounted on the equatorial stand built by Repsold in 1886 to carry the 7-in. heliometer. The reflector and the 7-in. Merz refractor have been mounted side by side so that the refractor can be used either as a guiding telescope or independently for observing double stars. While the reflector is intended almost exclusively for photoelectric photometry, provision is being made for photography at the Cassegrain focus. Various other alterations have been made, including an almost entirely rebuilt stand, a new electric drive incorporating a Grubb type control and an independent two-speed electric slow-motion, transference of the main driving wheel from the top to the bottom of the polar axis, arrangements for setting directly in right ascension instead of in hour angle, and alterations to the shutter on the old heliometer dome.

"Observations and Reductions" deals with the usual work with the reversible transit circle, including observations for the "Second Cape Catalogue for 1950.0", begun in 1951. Some consideration has been given to the composition of the next catalogues to be observed with this instrument, and two interlinked programmes seem to be equally urgent. The first of these is the observation of the various groups of standard stars in as fundamental a way as possible; the second is the extension of the resulting fundamental system to a sufficient number of stars to ensure the adequate reduction of photographic observations. Details of the scope of the schemes are given. Among the other usual subheadings reference may be made to Eros; measurement and reduction of forty-six plates of this minor planet which were taken during the 1954 opposition have been completed. About twelve reference stars per plate were used to reduce the effect of errors in their adopted proper motions, and a very interesting by-product of the investigation was the light it threw on the sizes of these errors. The proper motions from the Cape Astrographic Zone Catalogues, which were obtained by the differential measurement of two sets of photographic plates, are markedly superior, as regards relative accidental errors, to those in the more recent Cape and Yale Zone Catalogues which were obtained by comparing a photographic plate with an earlier meridian place.

Under "Meteorological Observations", reference is made to the Halliwell–Dines anemobiograph, in use since 1924, which had been giving considerable trouble through small leaks in the float. It was finally dismounted and replaced by the South African Meteorological Department with a Dines pressure-tube anemobiograph which was brought into use on August 12. Among other headings are "The Radcliffe Section", "The Time Service", "Publication of Results", "Personnel Establishment" and also "Miscellaneous", in which Dr. R. H. Stoy, H.M. Astronomer at the Cape, pays tribute to the work and enthusiasm of his staff.

* Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty, for the year 1955. Pp. 10. (Royal Observatory, Cape of Good Hope, 1956.)

ICE-FORMING NUCLEI

By DR. B. J. MASON and J. HALLETT
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IN an earlier communication[1] we reported on the ice-nucleating ability of a variety of chemical aerosols when introduced into a supercooled cloud formed in a diffusion and a large mixing-cloud chamber. Except in the case of silver iodide and lead iodide, these results were in disagreement with those of other workers in that we found many of the substances reported as highly effective ice-nuclei in the literature (notably silver nitrate, silver sulphate, the iodides of ammonia, potassium, sodium, cobalt, magnesium, manganese and thallium) to be quite inactive. Repeated tests with very pure chemicals in carefully cleaned air suggested that spurious results

may be obtained if trace contaminants (particularly silver, lead and iodine) are present in the air or in the chemicals. Finely dispersed silver salts were found to react with iodine vapour in low concentrations to produce particles of silver iodide, while the decomposition of certain iodides in an atmosphere containing traces of silver aerosol may produce a similar result.

The investigations have now been extended to include tests on new substances and, in particular, it has been established that minute crystals of iodine act as ice-forming nuclei at temperatures below − 14° C., and it is confirmed that cupric sulphide, dispersed as a finely-ground powder, nucleates a supercooled cloud at temperatures below − 6° C.

The diffusion cloud chamber was operated in the manner described in our first paper, but the original mixing-cloud chamber was abandoned in favour of a closed system which could be kept scrupulously clean and free from contamination by laboratory air. A five-litre 'Pyrex' flask fitted with ground-glass inlets, having been baked at 150° C. for two hours and rinsed with steam to drive off adsorbed traces of iodine from its walls, is flushed for several minutes with clean, filtered air. It is then immersed in a thermostatically controlled refrigerator, flushed with clean air until cooled to the required temperature and then sealed. After the air inside the flask has reached a steady temperature as indicated by three suitably disposed thermocouples, the chemical under test is introduced as a fine aerosol, and a supercooled cloud is formed by injecting a small quantity of warm distilled water through a side tube. The appearance of ice crystals is detected by their glittering in an intense beam of light traversing the chamber. The whole unit has to be thoroughly cleaned or replaced by a new one for each experiment.

Iodine as an Ice-nucleating Agent

Published evidence as to the ice-nucleating ability of iodine is conflicting. While Hosler[2] and Birstein and Anderson[3] reported that the introduction of iodine vapour into a mixing-cloud chamber produced ice crystals at temperatures above − 20° C., Pruppacher and Sänger[4] find it to be inactive. We found that when iodine vapour, produced by heating the crystals on a spectroscopically pure nickel wire, was introduced into the top of a diffusion cloud chamber, no significant number of ice crystals appeared at temperatures above − 40° C.[1].

We now find that if a fairly large iodine crystal, initially at room temperature, is plunged into a cold mixing-cloud chamber, myriads of sparkling crystals appear within a few seconds if the temperature is below − 14° C., this value appearing to be quite critical. These particles were ascertained to be ice crystals by collecting some on a cold microscope slide and examining them under a microscope placed in the cold chamber; they were observed to melt when warmed above 0° C. Also, when the air in the chamber was dried to below ice saturation over phosphorus pentoxide the crystals evaporated, but reappeared when the water vapour was restored. The possibility that the ice crystals were forming on silver iodide nuclei produced by the iodine vapour reacting with small traces of silver in the air seemed remote in view of their abundance and the fact that they first appeared at − 14° C. instead of at about − 5° C., the usual threshold temperature for silver iodide. It appeared rather that the vapour from the warm iodide crystal was subliming in the cold environment of the cloud chamber to form tiny, invisible crystals of iodine which, at temperatures below − 14° C., acted as ice-forming nuclei.

To establish this point more firmly, more careful experiments were conducted in the closed glass mixing-cloud chamber. The glass vessel, having been flushed and filled with clean, aerosol-free air, was sealed and cooled slowly to − 20° C. A warm iodine crystal followed by a few drops of distilled water were then introduced through a side tube, but neither ice crystals nor water droplets appeared. When, however, the same procedure was repeated but preceded by the introduction of a little room air, or aerosol produced by heating a spectroscopically pure nickel wire, ice crystals appeared in large numbers at temperatures below − 14° C. The introduction of a further iodine crystal caused a marked increase in the number of ice crystals. These tests indicated that aerosol particles were necessary to provide nuclei for the sublimation of iodine crystals which then acted as bases for the deposition of ice. Having established the mode of action of iodine as an ice-forming nucleus, as distinct from its reaction with particles of silver to produce silver iodide nuclei, it seemed necessary to re-examine our earlier findings that the introduction of iodine vapour into the top of a *diffusion cloud chamber* produced no ice crystals at temperatures above which water droplets freeze spontaneously. The chamber was set up as described in the earlier paper, the water source being heated to 25° C., to provide a large flux of vapour. After several hours the aerosol had 'rained out' to leave the air highly supersaturated relative to water. Iodine vapour, produced by heating iodine crystals in clean, filtered nitrogen, was passed into the top of the chamber. Apart from a few odd crystals appearing almost immediately at the − 15° C. level, there was no apparent result, indicating that in the absence of aerosol particles, the iodine vapour could produce neither droplets nor crystals. When the experiment was repeated with the iodine vapour being carried over by atmospheric air instead of filtered nitrogen, a dense droplet cloud was produced at all levels in the chamber, but again no significant number of ice crystals appeared above the − 40° C. level. This suggested that the iodine formed condensation nuclei and, being in solution, had lost its ice-nucleating ability. To confirm this, the chamber was modified to work under conditions of sub-water saturation. The introduction of iodine vapour in dried room air produced no droplet cloud, but large numbers of ice crystals now appeared below the − 17° C. level.

Nucleating Properties of some other Substances

In the first paper, experiments were described which strongly indicated that silver nitrate and silver sulphate were *not* effective ice-nucleating substances, the results obtained by other workers being attributed to the presence of traces of iodine in their apparatus which would react with the silver to produce silver iodide. This view has been confirmed in further tests in which aqueous solutions of silver nitrate, silver sulphate, and also lead nitrate and lead chloride were sprayed as very fine aerosols into the closed mixing-cloud chamber, cleaned and filled with filtered air as described above. The introduction of these salts produced no significant numbers of ice crystals at temperatures down to − 20° C.; but in

Fig. 1. The seeding of a supercooled film by nuclei of cupric sulphide

the case of the silver salts, when a small iodine crystal was dropped into the chamber, copious ice crystal formation occurred, even at − 6° C., indicating that silver iodide nuclei were being formed in great numbers. With the lead salts, the addition of an iodine crystal produced no ice crystals unless the temperature was below − 14° C., when they were no doubt initiated by the action of the iodine itself and not by the formation of lead iodide, which is normally effective at − 7° C.

In some preliminary tests with commercial grade cupric sulphide dispersed as a powder we found that ice crystals appeared in both the diffusion and mixing-cloud chambers at temperatures below − 15° C.; but we were unable to confirm the result announced by Pruppacher and Sänger[4] that the substance is a highly effective nucleator at temperatures below − 6° C. Recently, however, we have received from Prof. Sänger a sample of very pure cupric sulphide, specially prepared and finely ground. We also find that this material, dispersed by compressed air, readily nucleates a supercooled cloud at temperatures below − 6° C. and have been able to demonstrate its activity at this temperature in a rather striking manner by allowing a few very fine particles to fall upon a supercooled film. A film stretched across a wire hoop, six inches in diameter, was made by dipping the latter in a liquid detergent ('Stergene') containing about 10 per cent of water. Tests with nuclei of silver iodide, lead iodide and cupric sulphide showed that these initiated the growth of ice crystals in the film at threshold temperatures of − 5° C., − 6° C. and − 7° C., respectively, very close indeed to the threshold temperatures at which they nucleate a supercooled cloud. Fig. 1 is a photograph of crystals produced in the film at − 10° C. by cupric sulphide nuclei. After nucleation the crystals spread rapidly in the film and were sufficiently thin to show interference colours.

Similar tests made with finely powdered cuprous iodide made from 'Analar' copper sulphate and potassium iodide, and with vanadium pentoxide, indicated some increase in the concentration of ice crystals when the materials were introduced into a supercooled cloud at − 15° C.; but their activity increased rapidly with falling temperature to produce copious ice crystal formation at − 20° C. The vanadium pentoxide powder produced glittering particles even at temperatures above 0° C.; but its ice-forming ability was confirmed when it was observed to nucleate a supercooled film at − 15° C. Nucleation of the film by cuprous iodide also occurred at temperatures below − 15° C.

Cobaltous iodide, which has been reported by other workers as a highly effective seeding agent, failed to nucleate supercooled films at − 10° C., but produced some ice crystals below − 14° C. But because the compound is unstable, freely liberating iodine at room temperature, the appearance of ice crystals below − 14° C. is attributed to their formation on iodine crystals in the manner described above. In the experiments which reported cobaltous iodide active at − 5° C. the liberated iodine may have combined with contaminating traces of silver to produce nuclei of silver iodide.

Conclusions

We now have three chemical compounds which act as very efficient ice-forming nuclei: silver iodide (− 5° C.), lead iodide (− 6° C.) and cupric sulphide (− 7° C.), the figures in the brackets indicating the highest temperatures at which they produce ice crystals. A number of other substances become active at about − 15° C. and include crystalline iodine, cuprous iodide and vanadium pentoxide. The efficiency of silver and lead iodides may, perhaps, be attributed to their hexagonal symmetry with lattice constants quite close to those of ice (see Table 1). We have been able to grow perfectly oriented ice crystals on the basal face of a single crystal of lead iodide.

Table 1

Substance	Crystal form	Unit dimensions A.
Silver iodide	Hexagonal	$a = 4{\cdot}58$, $c = 7{\cdot}49$
	Cubic	$a = 6{\cdot}47$
Lead iodide	Hexagonal	$a = 4{\cdot}54$, $c = 6{\cdot}86$
Cupric sulphide	Hexagonal	$a = 3{\cdot}80$, $c = 16{\cdot}43$
Cuprous iodide	Cubic (zinc-blende)	$a = 6{\cdot}05$
Vanadium pentoxide	Rhombic	$a = 11{\cdot}48$, $b = 4{\cdot}36$, $c = 3{\cdot}55$
Iodine	Rhombic	$a = 4{\cdot}80$, $b = 7{\cdot}26$, $c = 9{\cdot}78$
Ice	Hexagonal	$a = 4{\cdot}52$, $c = 7{\cdot}37$

A similar explanation would not appear to hold for cupric sulphide, however, where the misfit on the basal plane is nearly 16 per cent, or for the other substances listed in Table 1. But it may be significant that cuprous iodide cleaves on the (011) plane in which the lattice spacings are 4·28 A. and 6·05 A. and that, in the grinding process, many faces of this orientation may be produced. Nevertheless, it is becoming apparent that the initiation and growth of ice on a foreign substrate is not determined solely by the lattice geometry of the latter, but that other properties such as the strength and configuration of the surface force field and, as indicated by our experiments on iodine, the solubility of the crystal may be important.

We would like to acknowledge the valuable assistance of Mr. Martin Baker in this work.

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1-AMINOCYCLOPROPANE-1-CARBOXYLIC ACID: A NEW AMINO-ACID IN PERRY PEARS AND CIDER APPLES

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DURING chromatographic investigations[1] of the amino-acid content of cider apple and perry pear juices, and of cider and perry, a substance was found which could not be identified with any previously reported naturally occurring amino-acid. This substance (hereafter called *X*) occurred frequently in the juices of perry pears, usually in small or trace amounts but occasionally as a major contributor to the amino-acids. Where *X* was present in the juice, it was also found in the fermented perry as a major component of the residual amino-acids; it therefore appears to be less readily assimilated by yeasts than are the commonly occurring amino-acids present in the juice. Small amounts of *X* were sometimes detected in apple juices and ciders.

A perry blend of Butt, Oldfield and Black Huffcap varieties was found to contain *X* in amounts sufficient to permit its isolation. Thirty litres of perry were passed through a column of 'Zeokarb 225' (H^+ form, 90 cm. × 3·8 cm. diameter) and, after washing with distilled water, the amino-acids were eluted with *N* ammonia; three other batches of perry were treated similarly. After evaporating *in vacuo* to small volume, the eluates were combined and gave a dark brown solution containing approximately 700 mgm. nitrogen (ammonia-free) derived from a total of 120 litres of perry. The amino-acids present in this solution are indicated chromatographically in Fig. 1. The yield of nitrogen in this preparation represented about 40 per cent of the total nitrogen of the perry (16 mgm. nitrogen/litre); the composition of the remaining 60 per cent present in the 'Zeokarb' percolate (10 mgm. nitrogen/litre) is unknown.

The crude amino-acid solution was partially decolorized with active charcoal ('Darco *G*.60') and fractionated on small columns of ion-exchange resins in four stages: (i) 'Zeokarb 225' (H^+), eluted with ammonia; (ii) 'Dowex 2' (OH^-), eluted with hydrochloric acid; (iii) 'Zeokarb 215' (H^+), eluted with ammonia; (iv) 'Dowex 2' (OH^-), eluted with hydrochloric acid. The segregation of *X* at each fractionation was detected by running one-dimensional chromatograms in *n*-butanol/acetic acid/water (65 : 10 : 25). A final yield of 254 mgm. of chromatographically pure *X* was obtained. It was purified twice by dissolving in a small volume of water and precipitating by addition of ethanol up to 95 per cent.

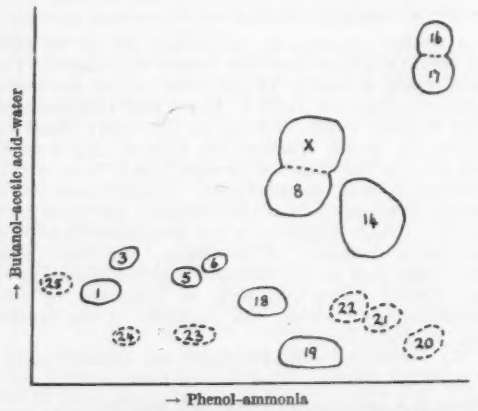

Fig. 1. Chromatogram of amino-acids from perry. (1) Aspartic acid; (3) glutamic acid; (5) serine; (6) glycine; (8) α-alanine; (*X*) new amino-acid; (14) methyl-hydroxyl-proline (ref. 2); (16) methyl-proline (ref. 3); (17) pipecolinic acid; (18, 19) peptides (probably); (20–25) unidentified (traces)

The white, needle-shaped crystals of *X* were very soluble in water and only slightly soluble in methanol, ethanol and acetone. No satisfactory melting point could be obtained because of decomposition occurring above 200° C. Its R_F value in *n*-butanol/acetic acid/water (65 : 10 : 25) was 0·25, in water-saturated phenol in the presence of ammonia vapour and potassium cyanide was 0·64 and in ethanol / 2*N* ammonia (4 : 1) was 0·43. On chromatograms dipped in 0·2 per cent ninhydrin in acetone and heated at 80° C. for five minutes, it gave a brownish spot which rapidly became purple on removal from the oven. This change was most characteristic and was probably due to the effect of atmospheric moisture, since it was inhibited by cooling the paper in a desiccator. It did not react with isatin but gave a pink colour with alloxan.

Hydrolysis with 6 *N* hydrochloric acid at 105° C. for 16 hr. had no effect on the chromatographic behaviour of *X* and it was therefore not a peptide. No colour was obtained with sodium nitroprusside and acetaldehyde[4], so *X* did not contain a secondary amino-group. On a chromatogram dusted with basic copper carbonate[5] and irrigated with water-saturated phenol, *X* ran as a copper complex (visible in ultraviolet light) near the solvent front and did not react with ninhydrin. It was therefore an α-amino-acid.

Sulphur and halogens were absent and elementary analysis showed its composition to be $(C_4H_7NO_2)_n$ (found: C, 47·9; H, 7·0; N, 14·1 per cent; O (by difference), 31·0 per cent; calculated: C, 47·51; H, 6·98; N, 13·85; O, 31·66 per cent). Molecular weight determination by Barger's method[6] indicated that $n = 1$ in the above formula. The substance *X* was therefore isomeric with azetidine-2-carboxylic acid and with the lactone of homoserine. It was, however, chromatographically distinct from both these substances (samples of which were kindly supplied by Dr. L. Fowden).

The presence of one carboxyl group per molecule was confirmed by formol titration. Allowing for the presence of a carboxyl group and a primary amino-group, the formula $C_4H_7NO_2$ requires either an unsaturated or a cyclic structure in the rest of the molecule (C_3H_4). The substance *X*, however, was unaffected by ozonolysis, so that the C=C linkage was excluded.

Catalytic hydrogenation of *X* gave two major reduction products and a smaller amount of a third. All three reacted with ninhydrin, and one of the major products was chromatographically identical

with α-amino *n*-butyric acid in three different solvents; the other two have not yet been identified*. The detection of more than one reduction product suggested the presence of alternative points of hydrogenation and indicated that the C_3H_4 moiety might be a cyclopropane ring.

The infra-red absorption spectrum of *X* supported this hypothesis and, since *X* was known to contain an α-amino-group, the probable structure was 1-aminocyclopropane-1-carboxylic acid. This substance was therefore synthesized by the method of Ingold, Sako and Thorpe[7], using the conditions of Dox and Yoder[8] for the condensation of ethylene bromide and diethyl malonate, to give ethyl cyclopropane-1 : 1-dicarboxylate. In the last stage of the synthesis, cyclopropane–spirohydantoin was hydrolysed by prolonged heating (21 hr.) with *N* sodium hydroxide to open the hydantoin ring and eliminate ammonia and carbon dioxide. The ammonia produced was removed by a stream of air into standard hydrochloric acid and back-titrated at intervals to give a measure of the progress of the reaction. The hydrolysate was finally acidified to expel carbon dioxide, and the 1-aminocyclopropane-1-carboxylic acid isolated by adsorption on a column of 'Zeokarb 225' (H^+) and elution with ammonia.

The product was recrystallized from 50 per cent aqueous acetone and had an elementary analysis C, 47·3; H, 6·9; N, 13·9; O (by difference), 31·9 per cent; (calculated: C, 47·51; H, 6·98; N, 13·85; O, 31·66 per cent). It was chromatographically identical with the natural amino-acid in *n*-butanol/acetic acid, phenol/ammonia and ethanol/ammonia and had the same characteristic ninhydrin reaction. The infra-red absorption spectra of the natural and synthetic amino-acids were identical in every detail and left no doubt that the compounds were the same.

Cyclopropane derivatives occur only rarely in Nature and the metabolic significance of this amino-acid is unknown. It is present in the juice of many perry pear varieties, having been found in seventeen out of twenty samples examined; it was, however, absent from the dessert varieties Conference and William's Bon Chretien. In a preliminary survey of other members of the Rosaceae family, it was not detected in alcoholic extracts of the following fruits: gooseberry, redcurrant, blackcurrant, raspberry, loganberry, blackberry, strawberry, quince and medlar (green).

It is intended to examine the distribution of this amino-acid in perry pears and related species and, if possible, to assess its metabolic role. Preliminary observations show that it appears during the last three to four weeks of ripening on the tree.

I am grateful to Dr. L. Fowden (University College, London) for carrying out a micro-catalytic hydrogenation on the natural amino-acid and chromatographic examination of the reduction products. Grateful acknowledgment is also made to Dr. D. H. Whiffen (University of Birmingham) for the infra-red absorption spectra of the natural and synthetic amino-acids and for the interpretation of the data. I thank Dr. A. R. Battersby (University of Bristol) for providing facilities for ozonolysis, and Dr. A. Pollard (Long Ashton Research Station) for helpful advice and discussion.

**Note added in proof.* Further catalytic hydrogenations have shown that the second major reduction product was α-amino *iso*-butyric acid and that both natural and synthetic amino-acids gave the same reduction products.

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HEPATOTOXIC ACTION OF PYRROLIZIDINE (*SENECIO*) ALKALOIDS IN RELATION TO THEIR STRUCTURE

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THE first alkaloids of the *Senecio* group were isolated about half a century ago from *Senecio latifolius* by Watt[1]; hence their name, and shortly after, Cushny[2] proved experimentally their hepatotoxic action in several species of animals. However, only in the past fifteen years has rapid progress been made in the elucidation of the structure of these alkaloids, after it was shown that retronecine and other necins (the basic products of hydrolysis of these alkamine ester alkaloids) are derivatives of pyrrolizidine[3]. Since then the chemical structure and the close interrelation of several pyrrolizidine alkaloids, even of those derived from plants belonging to different botanical families, have been established by several groups of workers (see review by Warren, ref. 4).

Much work on the biological effects of these compounds has been done by Chen, Harris and their co-workers at the Eli Lilly Laboratories[5]. These workers injected intravenously aqueous solutions of the alkaloids into several species of animal, and usually killed the surviving animals two to four weeks after the injection; on this basis they determined the *LD*50 of the compounds tested. However, in the light of more recent findings (see later) *LD*50 may not be a sufficient measure of liver damage. Several of the compounds considered then as individual entities proved to be mixtures or impure preparations when tested by paper chromatography and other new methods. Thus, pterophine, hieracifoline and carthamoidine have been shown to be mixtures of senecionine and seneciphylline, while jacodine and α-longilobine have been identified with seneciphylline, and β-longilobine with retrorsine[4].

The recognition that plants containing these alkaloids have been responsible for poisoning live-

stock (horses, cows and sheep) originally stimulated these studies. New interest in pyrrolizidine alkaloids is due to the finding that they produce primary liver tumours in rats[6], and to the possibility that their presence in some herbal remedies may be responsible for some of the liver disorders encountered in tropical and sub-tropical countries[7].

Recently it was shown that a single dose of lasiocarpine, a pyrrolizidine alkaloid from *Heliotropium europeum* L., can produce in rats severe liver lesions sometimes clinically apparent only many months after the treatment. During the symptom-free period following the ingestion of the alkaloid, the only evidence of its action was sometimes the presence in the liver of cytological abnormalities (Schoental, R., and Magee, P. N., unpublished results).

Several other pure crystalline pyrrolizidine alkaloids were also tested in rats by the administration of single oral doses, and all produced liver lesions essentially similar to those due to lasiocarpine. For generous gifts of these alkaloids I am greatly indebted to Drs. Roger Adams and B. L. van Duuren (monocrotaline and riddelliine), Dr. R. H. F. Manske (seneciphylline), and Drs. C. C. J. Culvenor, L. J. Drummond and J. R. Price (heliotrine and lasiocarpine). Lasiocarpine-N-oxide was prepared from the latter according to the procedure of Culvenor *et al.*[8]. The results, summarized in Table 1, illustrate the great variability of response as expressed by the survival time of the rats. Times of survival are not necessarily a measure of the liver damage, as intercurrent pulmonary infections and gastro-intestinal hæmorrhage frequently caused death before the liver lesion was fully developed.

Table 1. Survival Times of Rats in Relation to the Dose of some Pyrrolizidine Alkaloids

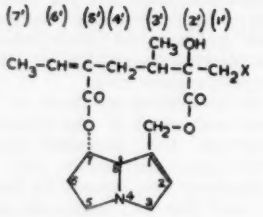
Alkaloid	No. of rats	Dose (mgm./kgm.)	Time until death (days)	No. of rats	
				Died	Surviving
Seneciphylline	6	100–200	1–3	6	
	26	50–100	2–61	26	
	20	25–40	14–91	11	9 (8 months)
Riddelliine	15	50–125	2–15	15	
	20	25–40	8–48	12	8 (3 months)
Monocrotaline	12	75–125	10–52	12	
	8	24–40	12–59	2	6 (3½ months)
Heliotrine	20	150–300	2–60	9	11 (8 months)
Lasiocarpine	17	100–150	2–128	17	
	28	75–99	2–385	14	14 (13 months)
	20	50–74	128–132	2	18 (13 months)
Lasiocarpine N-oxide	9	50–150	2–24	9	
	6	30–45			6 (3½ months)

While much more systematic work is required in order to be able to establish accurately the relation between the structure and the biological action of these alkaloids, the data so far available permit approximate assessment to be made of the essential features in the chemical structure of the pyrrolizidine alkaloids which are responsible for their hepatotoxic action.

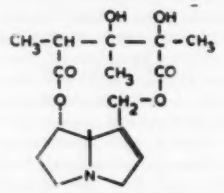
The structures of some of the alkaloids which have been tested for hepatotoxic activity are given in Fig. 1.

The double bond in the pyrrolizidine moiety of the alkaloids appears essential for their hepatotoxic action; platyphylline, which differs from senecionine

Cyclic Esters

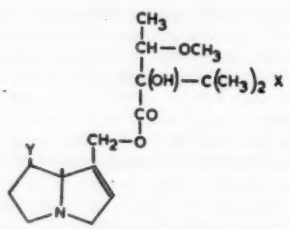


X = H; Platyphylline (*cis*); Δ^1 absent
X = H; Senecionine (*cis*)
X = OH; Retrorsine (*cis*)
X = H; Integerrimine (*trans*)
X = H; Seneciphylline (*cis*); double bond present at $C_{1'}:C_{2'}$
X = OH; Riddelliline; double bond present at $C_{1'}:C_{2'}$



Monocrotaline

Open Esters



X = H; Y = OH; Heliotrine
X = OH; Y = $CH_3CH:C(CH_3)COO$; Lasiocarpine

Fig. 1

only by the absence of this double bond, has been reported by Chen *et al.*[9] as having no effects on the liver, even in lethal doses. These workers reported also that no liver damage resulted from the administration of the products of hydrolysis of the alkaloids, retronecine, retronecic lactone and monocrotalic acid. Similarly, senecifolidine (identified later as retronecine[4]) did not produce liver damage when tested by Cushny[3]. Thus, the intact ester structure seems essential for the acutely hepatotoxic activity. It remains to be shown whether the products of hydrolysis are also unable to produce delayed effects, such as primary liver tumours.

On the basis of their structure, the alkaloids can be divided into two groups, depending on whether they are cyclic or open esters (Fig. 1). The former can be subdivided according to the size of the cycle. The cyclic diesters which have ten carbon atoms in the cycle all proved to be very effective in inducing liver damage. Monocrotaline, having only nine carbon atoms in the cycle, has in addition a pronounced effect on the lungs[10]. Variations in the acidic moieties of the alkaloids, such as the presence of an

additional hydroxyl group, or a double bond, a *cis*- or a *trans*-configuration at the ethylidenic carbon atom, appear to have little, if any, effect on the biological properties[8].

Among the alkaloids of the open ester structure, lasiocarpine, a diester, proved to be more effective than heliotrine, a monoester, which has the secondary alcoholic hydroxyl unesterified. The presence of an additional hydroxyl group in lasiocarpic acid would not be expected to affect the activity much, by analogy with such changes in the cyclic esters.

It is not yet possible to assess directly whether the stereochemical configuration of the pyrrolizidine moiety is of importance. In view of the similarity of the liver lesions produced by lasiocarpine (a derivative of heliotridine) and by the cyclic diesters (derivatives of the stereoisomeric retronecine), this seems likely to be of only minor significance.

Pyrrolizidine alkaloids are often present in the plants in the form of their N-oxides, especially during the growing and flowering period. Lasiocarpine-N-oxide proved as effective as lasiocarpine in producing liver lesions. Similarly, retrorsine, and its N-oxide, isatidine, both produced primary liver tumours when administered intermittently in drinking water[6]. The reduced and the oxidized forms of the alkaloids are readily interconvertible, depending on the redox-potential; it seems, therefore, not surprising that their effects are similar in the animal body.

So far, nothing is known about the mechanism by which these water-soluble substances produce delayed liver damage. Platyphylline, an alkaloid with a reduced double bond, and the products of hydrolysis of the alkaloids, have been reported inactive in this respect.

Besides reduction and hydrolysis, other possible metabolic changes are oxidation and/or incorporation into essential cell constituents. Oxidation to N-oxides has been shown not to interfere with the effectiveness of the alkaloids. Further oxidation could conceivably yield epoxides, compounds known to possess high reactivity, especially when formed *in situ*.

I wish to thank Dr. J. M. Barnes for his interest and help.

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HYDROLYSIS OF ADENOSINE TRIPHOSPHATE BY MITOCHONDRIAL PREPARATIONS

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LIVER mitochondria, freshly prepared in isotonic sucrose, are unable to hydrolyse adenosine triphosphate at an appreciable rate[1], but acquire this property upon the addition of dinitrophenol, or after various treatments which damage the structure of the mitochondria. Coincident with the development of increased adenosine triphosphatase activity, the mitochondria lose the ability to bring about oxidative phosphorylation. Interest in the mechanism of the hydrolysis of adenosine triphosphate was stimulated by the suggestion that it may be due to a reversal and diversion of the reactions which are responsible for its synthesis during the process of oxidative phosphorylation[2]. Some of the properties of the enzyme systems responsible for the hydrolysis of adenosine triphosphate are reported in this preliminary communication.

A study of the *p*H-activity curves of the hydrolysis of adenosine triphosphate under various conditions revealed the presence in liver mitochondria of four different enzymes (or enzyme systems) which bring about this reaction. The shapes of the curves were essentially the same when the system was buffered by *tris*(hydroxymethyl)aminomethane–acetate, *tris*-(hydroxymethyl)aminomethane – hydrochloric acid, histidine–hydrochloric acid, sodium 5,5-diethylbarbiturate, imidazole–hydrochloric acid or by the adenosine triphosphate itself. At all *p*H's, the rates of hydrolysis of glyceryl phosphate, adenosine-5-monophosphate, adenosine-5-diphosphate and inorganic pyrophosphate were very slow compared with that of adenosine triphosphate, in the presence of dinitrophenol. The hydrolysis of the diphosphate, but not of the other compounds, was stimulated by dinitrophenol, but this can be explained by the combined action of myokinase and the adenosine triphosphate-hydrolysing systems.

The four enzymes hydrolysing the triphosphate will be designated by the positions of the *p*H-optima, namely, at 6·3, 7·4, 8·5 and 9·4. The different curves often overlapped one another to give peaks at intermediate *p*H values, but it was possible under appropriate conditions to demonstrate the presence of each enzyme separately from the others.

9·4 *Enzyme.* This is the only enzyme which is appreciably active in freshly prepared liver mitochondria, in the presence of ethylenediamine tetra-acetate and the absence of uncoupling agents (curve 1, Fig. 1, *A*). This activity is not due to irreversible structural damage, caused by the high *p*H, since after standing at *p*H 9·4 and then neutralizing, the liver mitochondria still showed little activity at the lower *p*H's. The 9·4 enzyme is not stimulated by the addition of dinitrophenol (up to 10^{-3} *M*), but is

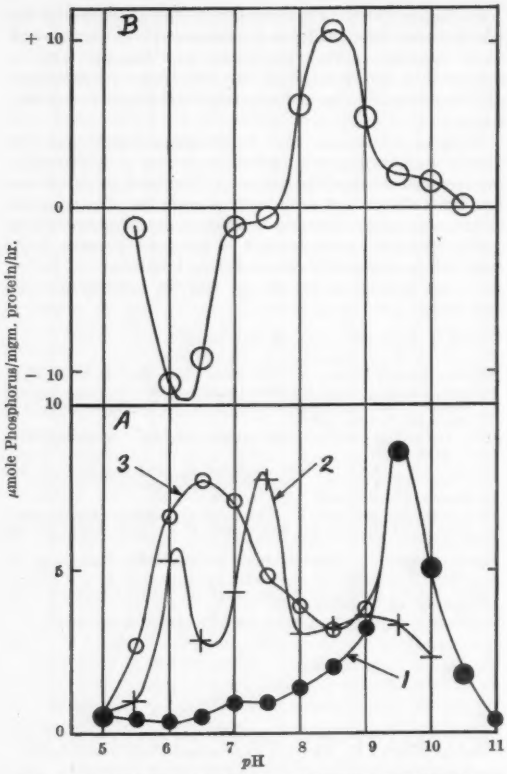

Fig. 1. *A*, hydrolysis of adenosine triphosphate by liver mitochondria under different conditions. In each case, the reaction mixture contained potassium chloride, 0·075 *M*; sucrose, 0·05 *M*; adenosine triphosphate, 0·002 *M*; *tris*(hydroxymethyl)-aminomethane–acetate buffer, 0·05 *M*; magnesium chloride, 0·001 *M*; liver mitochondria, 0·104 mgm. protein/ml. Curve 1, ethylenediamine tetraacetate, 0·0006 *M*. Curve 2, no addition. Curve 3, ethylenediamine tetraacetate, 0·0006 *M*; dinitrophenol, 10^{-5} *M*

B, difference curve plotting the adenosine triphosphatase activity of liver mitochondria in the presence of 10^{-3} *M* dinitrophenol *minus* the activity in the presence of 10^{-4} *M* dinitrophenol. Reaction mixture: potassium chloride, 0·075 *M*; sucrose, 0·05 *M*; adenosine triphosphate, 0·002 *M*; *tris*(hydroxymethyl)-aminomethane–acetate buffer, 0·05 *M*; ethylenediamine tetraacetate, 0·001 *M*; liver mitochondria, 0·06 mgm. protein/ml. No added magnesium

markedly activated by incubation of the mitochondria at 30° C., and is further activated by repeated freezing and thawing of the incubated preparation.

8·5 *Enzyme.* This enzyme, like the 7·4 and 6·3 enzymes, is stimulated by dinitrophenol, but requires a higher concentration of this reagent for full activation. It is most clearly demonstrated by plotting the difference between the *p*H-activity curves, in the presence of 10^{-3} *M* and 10^{-4} *M* dinitrophenol (Fig. 1,*B*).

7·4 *Enzyme.* The peak of this enzyme is usually obscured by the presence of neighbouring peaks. A clear inflexion in this region is, however, often obtained (for example, see Fig. 1, *B*). A clear peak is obtained at 7·4, when the measurements are made in the absence of ethylenediamine tetraacetate, either in the presence or in the absence of dinitrophenol (for example, see curve 2, Fig. 1, *A*).

6·3 *Enzyme.* This is the only enzyme clearly activated by 10^{-5} *M* dinitrophenol (curve 3, Fig. 1, *A*) or by calcium or azide. It is further activated by 10^{-4} *M* dinitrophenol, but inhibited by 10^{-3} *M* dinitrophenol, as is clearly seen by the difference curve in Fig. 1, *B*. A peak at this *p*H is also shown in curve 2, Fig. 1, *A*. This enzyme is also activated by incubation for 2 hr. at 30° and, unlike the other three enzymes, is not further activated by freezing and thawing the aged mitochondrial suspension.

All the enzyme systems in aged mitochondrial preparations are activated by Mg^{++}, Mn^{++}, Co^{++}, Zn^{++}, Sn^{++}, Fe^{++}, Cd^{++}, Ni^{++} or Be^{++}, but not by Ca^{++}, Ba^{++}, Cu^{++} or Al^{+++}.

The *p*H-activity curve of rat-heart sarcosomes (mitochondria), in the presence of 10^{-4} *M* dinitrophenol, is similar to that of liver mitochondria, but the specific activity is about 2·5–3 times as great. Ageing, followed by freezing and thawing of the sarcosomes, causes a further rise in the activity, as is the case with the liver mitochondria. The specific activity of such preparations is about twice that of liver preparations treated in the same way. The Keilin and Hartree horse-heart muscle preparation, which consists of sarcosomal fragments, gives a *p*H-activity curve similar to that of fully activated rat-heart sarcosomes or rat-liver mitochondria.

None of these enzymes, activated by 10^{-4} *M* dinitrophenol, is affected by 10^{-3} *M* potassium cyanide; 10^{-3} *M* potassium cyanide + succinate; pre-incubation with potassium cyanide so as to inactivate succinic dehydrogenase[3]; 0·01 *M* malonate; 10^{-6} *M* antimycin; incubation with 0·02 *M* 2:3 dimercaptopropanol for 3 hr.; treatment with sodium chloride to remove cytochrome *c*; addition of dinitrophenol to aged preparations, or of reduced diphosphopyridine nucleotide to normal preparations; α-tocopherol; vitamin K_1. These results make it unlikely that components of the respiratory chain are directly concerned in the mechanism of hydrolysis of adenosine triphosphate, as implied in a number of schemes of the mechanism of oxidative phosphorylation[4]. To accommodate these results, it is necessary to introduce an additional step in the reaction scheme previously proposed[4], thus

$$(1)\quad AH_2 + B + I \rightleftharpoons A \sim I + BH_2$$
$$(2)\quad A \sim I + X \rightleftharpoons X \sim I + A$$
$$(3)\quad X \sim I + \mathrm{ADP} + H_3PO_4 \rightleftharpoons X + I + \mathrm{ATP}$$
$$(4)\quad X \sim I + H_2O \xrightarrow{(\mathrm{DNP})} X + I$$

AH_2 and B are adjacent members of the respiratory chain, I replaces C in the previous scheme, following the suggestion of Chance and Williams[5], and X is the additional component, which is also indicated by the kinetic evidence of Chance and Williams[5]. The reverse of reaction (3), followed by reaction (4), is responsible for the hydrolysis of adenosine triphosphate.

It is possible that the three enzyme systems designated the 6·3, 7·4 and 8·5 enzymes, which are stimulated by dinitrophenol, are related to the three steps in the respiratory chain, which are coupled with phosphorylation. In terms of the above scheme, the three enzyme systems may involve different I's or X's.

Full details will be published elsewhere.

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LETTERS TO THE EDITORS

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Decomposition of Barium Azide

PREVIOUS studies of the decomposition of barium azide have shown[1] that the reaction proceeds at the interface between the anhydrous azide and discrete nuclei of metallic barium formed on the surface. The nuclei are formed at a rate proportional to the square of the time and, when large, grow at a constant rate with an activation energy of 25 kcal./mole. These conclusions were derived from experiments on imperfect crystals; the present communication reports results obtained on relatively perfect crystals and indicates the importance of localized macroscopic imperfections.

Large (5 mgm.) crystals of barium azide monohydrate, grown under carefully controlled conditions, were dried and dehydrated slowly *in vacuo* at room temperature. The decompositions were carried out *in vacuo* on a heated microscope stage using a magnification of 500 ×. As noted earlier, the rate of nucleus formation was initially proportional to (time)[3], but in the more perfect regions of the crystal it was observed that nucleation ceased abruptly at a critical density of nuclei (Fig. 1). In scratched crystals, nucleus formation occurred along scratch marks whether these had been made before or after dehydration, confirming that nuclei are preferentially formed at superficial imperfections.

When newly formed, the nuclei are circular and grow radially at an increasing rate until they reach a diameter (D) between 2 and 6μ. Growth then proceeds at a constant rate until they attain a critical size varying from 6 to 30μ, determined by the extent of the local lattice disarrangement (Fig. 2). The nuclei then become diamond-shaped, the rate of increase of the perpendicular distance (A) between opposite faces being constant and about twice as fast as the radial rate of growth of the circular nuclei. The activation energy for growth is 23 kcal./mole for both types of nuclei.

Thomas and Tompkins[2] suggested that the slow growth of small nuclei could account for the kinetics of decomposition of barium azide, and this is the first experimental confirmation of the phenomenon for azides. It is proposed that the entropy of activation, which largely determines the pre-exponential factor for growth, is initially small for small nuclei, but that, due to plastic flow initiated at the barium azide/barium interface by recrystallization of the metallic barium as the nucleus grows, it increases to a constant value which is independent of direction as long as growth still proceeds within the disorganized barium azide matrix. Once, however, the volume of the nucleus exceeds that of the disordered region the interfacial elastic strain, and hence the entropy term, becomes dependent on the barium azide crystal structure. The diamond nuclei grow faster than the circular nuclei, because the entropy of the undamaged lattice is lower than that of the disordered region. This effect will reduce the entropy of activation for circular nuclei if the activated state is the same in the two cases. It is evident that at the barium ordered lattice interface the entropy of

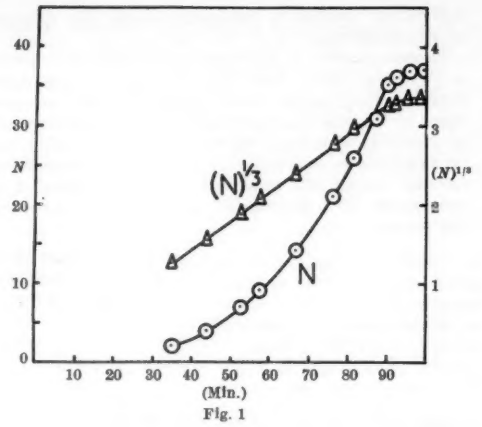

Fig. 1

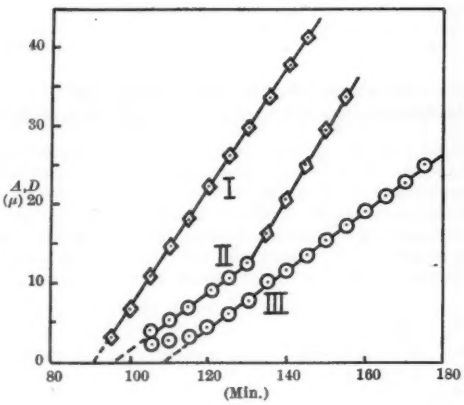

Fig. 2

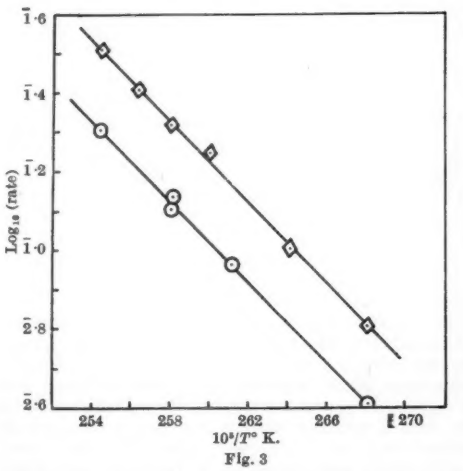

Fig. 3

Fig. 1. Number of nuclei (N) formed at 115° C. as a function of time. The plot obeys the function $N = c(t - t_0)^3$ where $t_0 \sim 0$

Fig. 2. The linear dimensions of nuclei as a function of time (115°). Nucleus I was formed at a small imperfection and nuclei II and III at successively larger imperfections

Fig. 3. Activation energy plot for nucleus growth. The rate is either (dA/dt) or (dD/dt)

activation reaches a maximum along the diagonals of the diamond.

It was further noted that all nuclei were circular in crystals which had been formed or dehydrated rapidly. This means that, apart from the re-assessment of the free energy of activation for slow growth, no modifications need be applied to the earlier work on precipitated samples, for with such materials only circular nuclei are expected. A more detailed discussion of slow growth in azides will be presented elsewhere.

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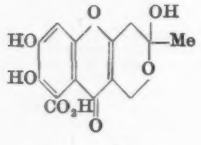
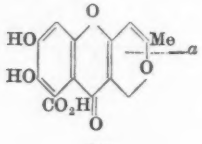
Fulvic Acid : its Structure and Relationship to Citromycetin and Fusarubin

Fulvic acid, $C_{14}H_{12}O_8$, is a yellow acidic metabolite produced by several fungi including *Carpenteles brefeldianum* Dodge (Shear) and was first isolated and characterized by Oxford, Raistrick and Simonart[1]. Investigations which have been carried out in this Department and which will be published in detail elsewhere enable us to formulate fulvic acid as (I).


(I)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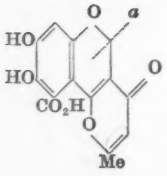
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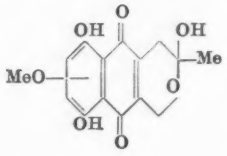
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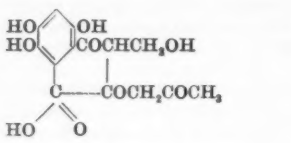
Fulvic acid is readily dehydrated, giving anhydrofulvic acid (II), which is isomeric with citromycetin[2] (III) from *Penicillium glabrum*. Oxford *et al.* have shown that fulvic acid is a dihydric phenolic acid and noted a general resemblance to citromycetin (III), which is now clearly due to the benzenoid system. We have observed, however, that fulvic acid (I) has many reactions in common with fusarubin[3] (IV), a pigment from *Fusarium solani*, and that fulvic acid and fusarubin are in fact isomeric when allowance has been made for the presence in the latter of a methoxyl group instead of a hydroxyl group. This methoxyl group has not yet been definitely located, but the reactions we encountered (for example, the ready dehydration) are clearly due to the terminal pyran systems.

Because we were impressed by these resemblances we analysed the structures of these metabolites into simpler patterns and found that all three could be reduced to the same fundamental structure (V), which, in this or an equivalent form, might therefore be considered a precursor of the three compounds. Structure (V) is reached from anhydrofulvic acid (II) or citromycetin (III) merely by conventional hydrolytic fissions of the pyrone rings and of the bonds marked (*a*). The connexion between (V) and fusarubin (IV) is less obvious, but consists chiefly in the linking of the carbon atoms connected by a dotted line in (V). For simplicity, one might suppose the carboxyl group in (V) to be reduced to hydroxymethyl (since there are many known sequences of natural products of which the members differ in the sense CH_3, CH_2OH, CHO, COOH), whereupon condensation of the new methylene group with the appropriate carbonyl group leads to a reduced naphthoquinone (VI) simply related to fusarubin (IV). It remains to be seen whether the methoxyl group does in fact occupy the position required by this hypothesis.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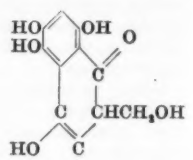
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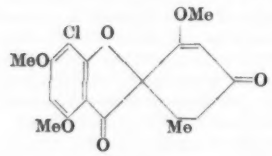
(VII)

C. brefeldianum produces fulvic acid when grown on Raulin–Thom media. On Czapek–Dox media, however, fulvic acid is not produced, nor is citromycetin or fusarubin. Instead, the chief metabolite is now griseofulvin[4] (VII), which cannot be readily related to fulvic acid except at the lowest level of acetate hypothesis[5]. It is of interest that variations in the environment of the fungus have a more profound effect on its metabolism than have variations in the species.

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Asymmetric Dialysis of Racemates

THE enantiomorphous forms of optically active compounds can, as a rule, be differentiated by living membranes and epithelia[1]. To establish the basic mechanisms of such asymmetric resolution, we have carried out experiments with artificial membranes of optically active material. As early as 1928, Keeser[2] demonstrated asymmetric diffusion; blocks of gelatine swelled better in solutions of the D-form of tartaric acid, cinchonine and epinephrine than with the L-enantiomorphs. It is therefore surprising that such properties as asymmetric resolution do not seem to have been demonstrated with well-known membranes, even if the membranes consisted of asymmetrical material such as 'Cellophane' or collodion (products of cellulose), or of the fresh mucosa of intestinal loops (products of proteins)[3], etc.

We tried to increase the asymmetry of the membrane by enriching it with optically active substances. A 4 per cent collodion solution in ether and ethyl alcohol was added to different alkaloid bases or their acetic or hydrochloride salts and poured out to become membranes. Water was kept on one side of the membrane, and a racemic acid, which is usually resolved by means of the base, on the other. But the measured rotations of the aqueous solutions were not sufficient for an asymmetric dialysis.

The best results were obtained with tartaric acid. As basic substance we used 2-(D-gluco-D-gulo-heptohexahydroxyhexyl)-benzimidazole, which is one of the best substances for the resolution of tartaric acid[4]. This glucoheptonic acid benzimidazole was dissolved in a 4 per cent alcohol–ether solution of collodion at about 35° C. and acidified with hydrochloric acid. With this membrane we obtained from D,L-tartaric acid a dialysed aqueous solution with a small rotation indicating optically active tartaric acid. We are attempting to improve this interesting method with a multiplicator procedure ('Multiplikator-Verfahren', see ref. 5).

Replacing the collodion membrane with 'Cellophane' dialyser tubing, another form of asymmetric dialysis was possible. If D-, L- and D,L-tartaric acid respectively was put into three tubes, together with the glucoheptonic acid benzimidazole (Table 1), the L-form was bound as a diastereomeric salt, and so the D-tartaric acid dialysed more quickly into the water phase, as was shown in experiments with the D- and D,L-forms. The rotation was about ten times greater than the experimental error. The total tartaric acid transferred was determined acidimetrically.

Table 1. ASYMMETRIC DIALYSIS OF TARTARIC ACID AND GLUCOHEPTONIC ACID BENZIMIDAZOLE AGAINST WATER THROUGH A 'CELLOPHANE' MEMBRANE

Procedure: Three portions of 0·9 gm. glucoheptonic acid benzimidazole dissolved in 20 ml. of a 1·25 per cent solution of D-, D,L- and L-tartaric acid and filled into 'Cellophane' tubing; dialysis against 40 ml. water, at 20° C.; in the outer fluid α_D^{20} was measured in a 200-mm. tube and afterwards 3·0 ml. was titrated with 0·1 *N* sodium hydroxide against phenolphthalein

Time in min.	D-Tartaric acid		D,L-Tartaric acid		L-Tartaric acid	
	Outside	Inside	Outside	Inside	Outside	Inside
	Rotations					
0	0°	+1·93°	0°	+0·85°	0°	+0·09°
30	+0·14°		+0·06°		+0·02°	
160	+0·23°		+0·10°		+0·07°	
180	+0·74°	+1·04°	+0·24°	+0·56°	+0·08°	+0·15°
	Acidimetric control					
180	1·42 ml.		1·52 ml.		0·97 ml.	

Table 2. Conditions and arrangement as in Table 1. 0·31 gm. D,L-tartaric acid and 0·28 gm. glucoheptonic acid benzimidazole dissolved in water to an end volume of 10 ml. as inner liquid; outside liquid is 20 ml. water

Time	Rotation	
	Outside	Inside
0 min.	0°	+ 0·45°
60 min.	+ 0·07°	
180 min.	+ 0·14°	
15 hr.	+ 0·18°	+ 0·11°

In another experiment with longer duration of dialysis, the asymmetric separation was also found (Table 2). The rotation in the outside liquid increased from 0° to + 0·18°, and decreased in the liquid inside from + 0·45° to + 0·11°. These differences are in good agreement within experimental error, if the rotation of the outside liquid is doubled on account of its doubled volume.

The semipermeable character of the 'Cellophane' membrane was controlled by the method of Wo. Ostwald[6]. Alkaline blue and congo red did not diffuse, congo rubin slightly, methyl violet considerably better.

Hence in the asymmetric dialysis of D,L-tartaric acid, D-tartaric acid is transferred through the membrane because L-tartaric acid forms a less dissociable salt with benzimidazole; so the remaining D-form is more readily transmitted.

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High-Intensity Flash Irradiation of Polymers

IN an attempt to shorten exposures in the ultraviolet irradiation of polymers, we have used as light sources high-intensity flash discharge lamps, described by Murphy and Edgerton[1], which have been used extensively in flash spectroscopy[2–4] and flash photolysis[5,6]. The lamps used were similar to Christie and Porter's fused silica spiral lamp No. III [7] and usually were flashed with 648 μf. at 4,000 V. (5,184 j.). Each flash lasted about three milliseconds, and by uranyl oxalate actinometry[8] was shown to yield $9{\cdot}6 \times 10^{19}$ quanta in the 2000–4900 A. region. The polymers were placed approximately along the axis of the lamp coil, either in fused silica or 'Pyrex' glass test-tubes, and were irradiated in air, streaming nitrogen, or *in vacuo*. In several polyethylenes, polystyrene, polyethylene terephthalate, poly*iso*-butylene, 6-10 nylon, polyvinylchloride, polytetrafluoroethylene, regenerated cellulose and cellulose acetate, we found that, in addition to some minor homogeneous photolysis, a single flash caused violent heterogeneous decompositions within the polymer matrices. These decompositions usually were accom-

Table 1. Weight Loss of 0·060 in. Polyethylene Sheet flashed at 31° C. in Air through Various Light Filters

Light filter	No. of flashes at 4,000 V.	Energy per flash (j.)	Weight loss (per cent)
Quartz (~1·4 mm.)	1	5,184	0·14
"	1	2,592	0·01
"	2	2,592	0·08
'Pyrex' (~0·9 mm.)	1	5,184	0·13
'Pyrex' (~2·2 mm.) + water (~8·0 mm.)	1	5,184	0·05
Opaque ceramic	1	5,184	0·00

panied by a sharp report, the formation of gas bubbles and carbon spots within the polymer, and the deposition of fluorescent (under mild excitation by 3000–4000 A. radiation) substances near centres of decomposition. These heterogeneous decompositions do not seem to depend on the chemical properties of the polymers but rather on the presence of particulate impurities within the polymer matrices. This is shown by: (1) the wide spatial separations among decomposed areas (0·5–5 mm.); (2) the transparency of many of the polymers in the wave-length region used; (3) the reproducibility of the decompositions when certain particulate contaminants are added to the polymers before irradiating; and (4) the fact that clean polyethylene taken directly from a polymerization reactor (this polyethylene was kindly supplied by Dr. S. W. Hawkins of Imperial Chemical Industries, Ltd.) undergoes very much less decomposition than polyethylenes that presumably have become contaminated during normal processing.

We have studied polyethylene in some detail. The decomposition of typical polyethylene sheets or pellets, prepared without scrupulous cleanliness, is unaffected by temperature, in the range − 196° to 125° C., and whether the sample is flashed in air, nitrogen or *vacuo*. In Table 1 are tabulated weight losses upon flashing polyethylene in air through various light filters and at different total energies. These weight losses show that the decompositions are (1) produced by radiation from about 3000 A. into the near infra-red; (2) strongly dependent upon total energy per flash; and (3) cumulative, increasing rapidly with successive flashes.

Mass spectrometer analysis of gases liberated during flash irradiation of polyethylene *in vacuo* show the presence of hydrogen, water, carbon monoxide, carbon dioxide, methane, and a series of hydrocarbons, of masses from 26 to 92, which are rich in unsaturates and aromatics. Also wax-like materials which melt considerably above room temperature are vaporized both from within the polyethylenes and from their surfaces. As is the case in other irradiations of polyethylenes[8], fragmentation, as described above, is accompanied by increase in the viscosity molecular weight of the remaining polymer. The dependence on experimental conditions of this molecular build-up appears to be complex, however, and requires further investigation.

To determine what sort of impurities cause this decomposition, relatively clean polyethylenes were doped by sealing together heat-softened sheets of the polymer, the inner faces of which had been sprinkled with traces of various powders. These laminates were placed in 'Pyrex' glass test-tubes and flash irradiated (648 μf. at 4,000 V.) in air at room temperature. The powders which produce decomposition are: carbon black, graphite powder, crushed arc carbon (both 100–120 mesh and passing 120 mesh), sodium fluorescein, ferric oxide and iron. Those which do not are: milled-in carbon black, crushed arc carbon (40–60 mesh), polymer carbon spheres (40–60 mesh)[10], aluminium oxide and titanium oxide.

A plausible explanation for our observations is that the decompositions are chiefly pyrolytic, initiated by nearly adiabatic black body heating of minute solid particles suspended in the polymer. This is analogous to the high temperatures encountered in homogeneous flash photolysis[8]. The dependence of decomposition on particle diameter in the case of the sieved and milled-in carbons is difficult to explain by non-thermal mechanisms. Of course, we have not ruled out heterogeneous photolysis as a mechanism.

Whatever mechanisms are operative, our observations show that the heterogeneous decompositions produced in polymers by flash irradiation usually can be prevented by scrupulous exclusion of impurities from polymers. The relationships among these heterogeneous decompositions produced by flash irradiation, ordinary thermal and outdoor degradations of polymers, and the mechanisms of carbonization are being investigated further.

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Ground-State Transitions in the Reaction $^{10}B(n,t)^{8}Be$

In a recent communication, Frye and Gammel[1] have reported a study of the reaction $^{10}B(n,t2\alpha)$ for bombarding energies in the range 6–20 MeV. They give evidence which suggests that the reaction proceeds either via lithium-7 as an intermediate nucleus or as a three-body break-up. Their results indicate that if beryllium-8 takes part at all in the reaction, it occurs only in a very small fraction of the events; and they particularly remark on the absence of events leading to the formation of beryllium-8 in the ground-state.

A similar good geometry experiment, using Ilford E_1 emulsions 200μ thick and loaded with the normal isotopic mixture of boric acid, has been carried out in this laboratory at a neutron-bombarding energy

Table 1

Event	Beryllium-8		Lithium-7 (case 1)		Lithium-7 case (2)	
	Q_1	Q_2 (MeV.)	E_1	E_2 (MeV.)	E_1	E_2 (MeV.)
1	−0·07	0·08	12·46	12·56	12·28	12·74
2	−0·18	0·08	12·72	11·91	13·32	12·27
3	0·01	0·01	12·61	12·70	12·78	12·94
4	0·01	0·07	12·55	12·47	12·74	12·99
5	0·04	0·21	11·82	11·83	13·45	13·66
6	0·08	0·10	13·58	13·58	11·92	11·93
7	0·75	0·01	13·02	12·01	12·80	11·81
8	0·47	0·85	13·43	13·34	11·13	11·08
9	−0·55	0·06	12·44	12·74	12·58	13·17

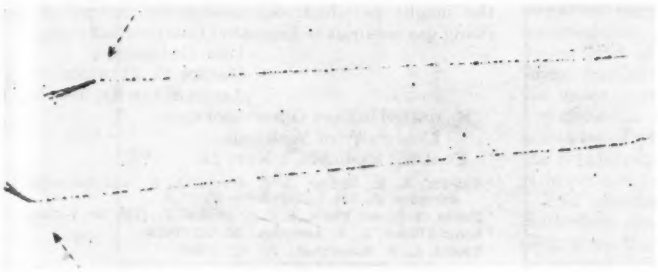

Fig. 1. Micrographs of events 1 and 3. The neutron direction has been indicated by an arrow for each event. Observers: Miss S. Miller and Mrs. L. Makunas

of 14·1 MeV. 360 three-particle stars have been identified by energy and momentum balance criteria as due to the reaction under discussion. Among them are nine stars which can be assigned to the reaction $^{10}B(n,t)^{8}Be$, the beryllium-8 nucleus being formed in the ground-state. For each star the instability of the beryllium-8 state above two α-particles can be calculated in two ways. First, from the energy of the triton and the angle it makes with the incoming neutron; and secondly, from the energy of the two α-particles and the angle between them. The results are presented in Table 1 and a micrograph showing two events is reproduced as Fig. 1.

It will be seen that the measured values cluster remarkably well about the generally accepted *Q*-value[2] of the beryllium-8 ground-state, namely, 0·096 MeV., except for events 7 and 8, which involve tracks at steeply dipping angles. If it is assumed instead of the above that these events arise from the reaction $^{10}B(n,\alpha_1)^{7}Li^{*}(t,\alpha_2)$, four energies for the lithium-7 excited state can be calculated for each event, depending on which α-particle is assumed to come first. For each chosen case the associated pair of energies should be in agreement. The results are listed in Table 1 and, although there is some spread in energy, could be regarded as involving a state of lithium-7 in the neighbourhood of 12·5 MeV. There is some evidence for such a state from $^{7}Li(\gamma,n)$ experiments[2], but we do not believe these events involve it for the following reasons.

(1) If they were due to the (n,α) reaction they would require a break-up of the lithium-7* nucleus in its centre-of-mass system such that the triton is thrown forward and the α-particle backwards. All events with a calculated lithium-7 excitation energy falling in the region (12·5 ± 1) MeV. were therefore examined and a histogram constructed showing the number of events with angle θ between the α-particle pair against θ. Sixty-four events qualified for the test and the result is shown in Fig. 2. The distribution is consistent with an isotropic break-up of the lithium-7* nucleus with the exception of the group of events under discussion, which fall in the interval 0–20°. These pairs of α-particles, closely correlated in direction, are not compensated by a corresponding group in the interval 160–180°, and this strongly implies that they are due to the $^{10}B(n,t)^{8}Be$ reaction.

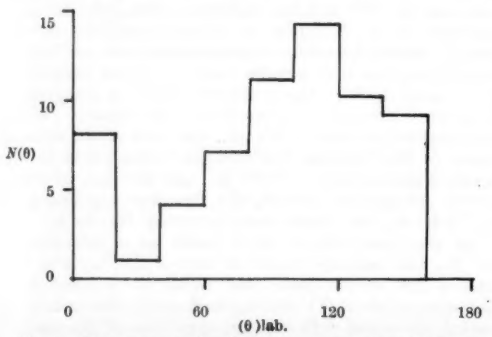

Fig. 2. Histogram showing $N(\theta)$, the number of events having angle θ between α-particle pair, against θ, the angle between the α-particles in the laboratory system

(2) In addition to this result there is the point that barrier penetrability considerations favour the emission of a high-energy triton over a low-energy α-particle from the compound nucleus, even though by only a small factor.

The present experiment therefore indicates that, contrary to the Los Alamos result, the reaction $^{10}B(n,t)^{8}Be$ does occur at a bombarding energy of 14·1 MeV., and the cross-section for transitions to the ground-state is about 3 per cent of the total cross-section of $^{10}B(n,t2\alpha)$. This result agrees with experimental results[3] on the reaction $^{11}B(\gamma,t)^{8}Be$, where, at similar excitation energies of the compound nucleus, a small fraction of the transitions are to the ground-state of beryllium-8.

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A Connexion between the Granulation and the Structure of the Low Chromosphere

Photographs of the solar spectrum made with the vacuum spectrograph of the McMath–Hulbert Observatory have revealed a variety of interesting and complex features in the structures of the Fraunhofer lines[1]. The appearance of the hydrogen line cores suggests an underlying, diffuse component that evidently originates in the photosphere, upon which are superposed a series of streaks that must be of chromospheric origin. The weaker metallic lines (of Rowland intensity less than about 10) also fluctuate in width and intensity and have a characteristic zig-zag appearance caused by the Doppler shifts of ascending and descending gas columns which are associated with the granulation in the photosphere.

On a plate of exceptionally good quality taken on July 8, 1955, U.T. 12h. 2m., over an apparently quiet region of the disk, it was noted that the majority of streaks in the Hβ line, which result from chromospheric structures about 2,000 km. in diameter, were associated with violet shifts in the neighbouring metallic lines. This apparent association was investigated in more detail on isophotes of the Hβ line

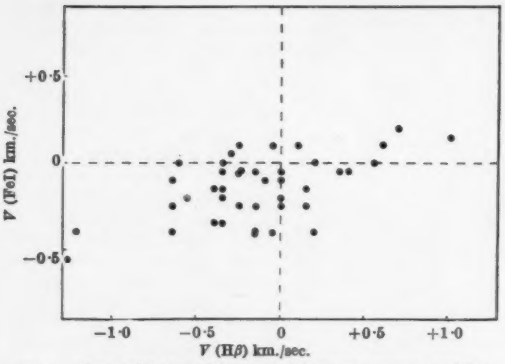

Fig. 1. Line of sight velocities derived from measurements of Hβ (abscissa) and Fe I λ 4859·747 (ordinate) in the solar spectrum. The negative and positive signs refer to motions toward and away from the observer, respectively

and of the nearby Fe I line λ 4859·747 constructed with a Babcock-type isophotometer[2]. Over an angular interval of 6·5 min. of arc, forty-one streaks in the Hβ line were measured for radial velocity, and similarly, velocity shifts were measured in the Fe I line, at points in the line corresponding to the positions of the Hβ structures.

The line of sight velocities for the two lines are plotted against each other in Fig. 1. Although the quantitative correlation between the two sets of velocities is not pronounced, the diagram has several very interesting features. First, there is a remarkable association of the Hβ structures with violet shifts in the Fe I line. Of the 41 measured Hβ structures, 30 are associated with violet shifts in the Fe I line, 7 with red shifts and 4 with zero shifts. Secondly, the Hβ structures are themselves predominantly shifted to the violet. The statistics show 26 violet shifts, 11 red shifts and 4 zero shifts. Thirdly, the velocity spread in the Hβ line is about three times as great as that in the Fe I line. The root mean square values of the Hβ and Fe I velocity shifts are 0·64 and 0·24 km./sec., respectively. Calculations indicate that if the Hβ line features are caused by the superposition of velocity-shifted chromospheric profiles upon a photospheric profile, the resulting combined profile will be asymmetric, and measurements from isophotes will tend to be too small by about a factor of two.

There are several possible explanations for connexion between the chromospheric structures and the Doppler shifts in the granules. The most obvious one appears to be that the structures observed in the hydrogen lines represent extensions of the granular columns into the low chromosphere. It is easy to estimate, for example, from the chromospheric model of Bohm-Vitense[3], that optical depth unity is reached for the centre of Hβ at a height of about 1,000 kilometres in the chromosphere, whereas at $\Delta\lambda = 0{\cdot}2$ A., to which the radial velocity measures refer, unit optical depth would be reached at a height of about 300 km. On the other hand, the core of the Fe I line would be formed near the top of the photosphere. Since over this range of heights the density is reduced by a factor of the order of 50, the increase of outward velocity with height along the column is not unreasonable[4].

It is possible that similar studies on lines formed at greater heights in the chromosphere than Hβ, such as Hα and the H and K lines of Ca^+, may reveal the height at which the mechanical energy of the rising gas columns is dissipated into thermal energy.

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Intensity of the Radio Line of Galactic Deuterium

The possibility of detecting deuterium in the galaxy by observation of a radio spectral line at a frequency of 327 Mc./s. has been discussed by Shklovsky[1]. He suggested that the line might be observable in absorption towards the galactic centre, a direction in which the background intensity of continuous radio emission is a maximum, and dispersion of the line by Doppler effect from galactic rotation is a minimum.

Measurements during 1954–55 by Getmanzev, Stankevitch and Troitsky[2], using an aerial of about 4 m. diameter, appeared to show an absorption line with unexpectedly strong intensity, corresponding to about 2° K. aerial temperature. This indicated a deuterium concentration relative to hydrogen of about 1 part in 300, an abundance ratio about twenty times greater than the terrestrial value[3]. At this time, a sensitive radiometer, originally designed by L. R. O. Storey, was being prepared at the Radar Research Establishment, Malvern, for an attempt to detect the deuterium line. Initial observations during 1955 with an aerial of 7·5 m. diameter and a temperature sensitivity of 1 deg. K. were reported[4], showing no indication of the line. A similar negative conclusion from Australian measurements in 1954 was afterwards published by Stanley and Price[5], who were unable to detect the line with an aerial of 24·5 m. diameter and sensitivity of 1 deg. K.

In view of the conflicting evidence, and the significance of the intensity of the line in determining the abundance of deuterium, the measurements have been pursued at Malvern with improved receiving apparatus. The radiometer is of the frequency-switching type and compares the signal received in a 'search' channel of 16 kc./s. bandwidth with that received in two similar reference channels on frequencies 72 kc./s. higher and lower than that of the search channel. The crystal mixer has an image rejector circuit and a noise factor of 3, as measured by a noise diode. The receiver output is integrated by a low-inertia d.c. motor driving a counter. With an integration time of 5 min., the root mean square value of the residual fluctuations corresponds to an aerial temperature of 0·35° K. At the end of each 5-min. integration period, the frequency is changed by 10 kc./s., the total sweep covering 100 kc./s.

As the observations were made at a latitude of 52° N., the galactic centre is above the horizon for only a few hours each day, rising to a maximum elevation of about 9°. During each daily observational period the aerial followed the direction of the centre automatically and four frequency-sweeps of 100 kc./s. were made. After rejection of about 25 per cent of

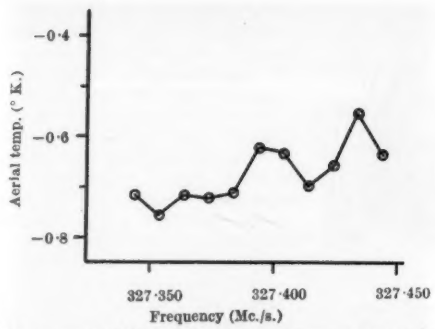

Fig. 1. Average of 14 days observations, uncorrected for receiver noise spectrum

the days because of disturbances attributable to interference, the remaining observations were corrected for Doppler frequency shift due to terrestrial motion. The average of the results for fourteen days is shown in Fig. 1, the root mean square value of the fluctuations corresponding to an aerial temperature of about 0·05° K. The large mean displacement of about −0·7 deg. K. is caused by the curvature in the spectrum of the receiver noise. To remove this displacement, control records were obtained 2 hr. before and 2 hr. after the observational run, with the aerial set respectively in the mean direction of the first and second halves of the run. This also helped to remove any part of the displacement which might be due to persistent low-level interference.

The final result is shown in Fig. 2, together with the expected ideal profile for a deuterium absorption intensity equivalent to an aerial temperature of 0·1° K. and 30 kc./s. line-width. The aerial temperature deduced from the observations has a mean value of about − 0·05° K. Although this could be taken to indicate absorption in the region of search frequency, there are alternative explanations. It could be caused by weak terrestrial interference received predominantly on one or both reference frequencies; or it might be due to the different intensity relationships of the continuous background

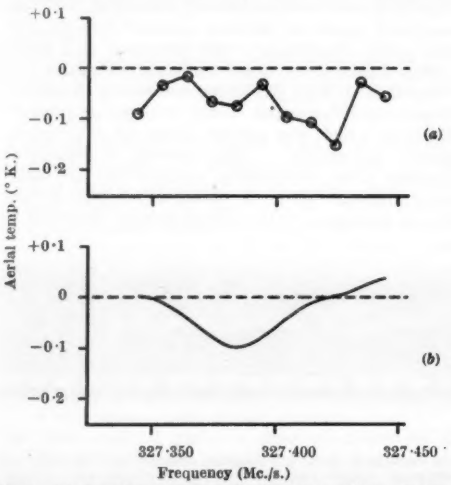

Fig. 2. (*a*) Corrected average of 14 days observations. (*b*) Expected profile for a line intensity corresponding to −0·1° K. aerial temperature

radiation during the control period. Despite these uncertainties, it is reasonable to set 0·1° K. as the upper limit of the intensity of deuterium absorption. These results represent an improvement in setting the lower limit of detection of deuterium absorption, for although Stanley and Price[5] with their larger aerial received about five times as much power from the continuous radiation, our temperature sensitivity is improved by a factor of 10.

The precise derivation of the abundance of deuterium from the intensity of absorption is complex, since the continuous galactic radiation originates in several different ways. The principal sources of high brightness temperature are the narrow belt of emission parallel to the galactic equator which is largely associated with H II regions[6], and a discrete source which is in the same direction but probably less distant than the galactic centre[7]; in addition, there is more widely diffused radiation of lower intensity. An approximate computation from our results leads to the conclusion that the average abundance of deuterium does not exceed 1/2,000 that of hydrogen.

Acknowledgment is made to V. A. Hughes for helpful discussion and assistance in making observations.

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Relation of 11-Metre Solar System Phenomena to Solar Disturbances

Three of the most important solar disturbances observed during 1956 were the great eruptive prominence of February 10 and the large flares of May 17 and August 31. For a week or two after each of these events, a sequence of phenomena involving Venus, the Earth and the Moon were observed with a radio telescope operating on a wave-length of 11 m.[1], these events appearing to be related to the preceding solar disturbance. In one case strong signals of apparent Venusian origin were observed a number of days after the solar disturbance, and a few days later a phenomenon was observed which, presumably, was caused by the presence of a large ion cloud near the Moon. Such a sequence of events suggests that a stream of particles ejected by the Sun and travelling earthward first encountered the planet Venus, resulting directly or indirectly in the production of strong 11-m. radio signals from Venus. Drifting farther out, the particles reached the vicinity of the Earth, with some of the particles forming a cloud near the Moon.

On February 10, 1956, there was a large solar prominence, which shot off the solar disk at very high velocity[2]. On February 18 a distinct interferometer pattern was obtained at the time of transit of the Moon through the antenna beam. The maxima of the pattern were characterized by many short static-like bursts of fractional second duration.

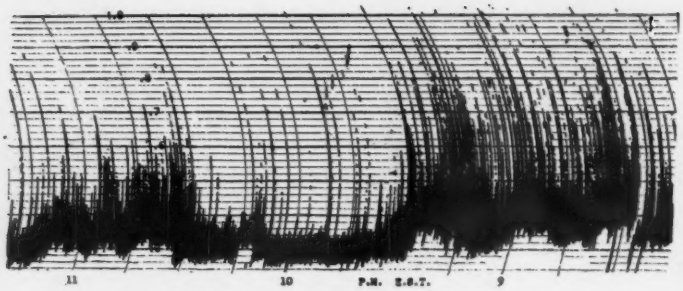

Fig. 1. 11-m. record obtained on September 16, 1956, during the transit of the Moon through the antenna beam

On May 17, 1956, there was a large solar flare rated as of importance 3 by the High Altitude Observatory[3], Boulder, Colorado. The events which followed were :

Date	Event	Time after first event
May 23	Strong Class I Venus signals	6 days
May 24	Strong Cygnus A scintillations	7 days
May 30	Strong Class I Venus signals	13 days
June 1	Strong Cygnus A scintillations	15 days
June 4, 5	Moon reflexions of Class II Venus signals	18, 19 days
June 5	Moon signals	19 days

On August 31 there was another solar flare of importance 3 and on September 16 a record (Fig. 1) was obtained during the transit of the Moon through the antenna beam. It is characterized by an elevated background-level with strong static-like bursts of duration of a fraction of a second superposed. The brevity and intensity of these bursts are indicated by the dashed and dotted appearance of many of the bursts caused by the fact that the recorder pen was deflected so quickly as to skip over parts of the chart. Patterns similar to Fig. 1 were also obtained for about four days prior to September 16, the indicated time of transit for the source being about 50 min. earlier on each preceding day. This observed motion corresponds closely to that of the Moon.

Referring to Fig. 1, the Moon was on the meridian at 10.12 p.m., E.S.T., and in the main beam from about 8.30 to 11.30 p.m. The interferometer pattern has three large lobes near 9 p.m. and a couple of smaller ones near 10.45 p.m. but with a very weak pattern between. Around 9 p.m. the background level is raised not only at the lobe maxima but also at the lobe minima. The magnitude of this effect indicates that the source must have been of the order of 1°–2° in angular extent. Furthermore, the nulls of the pattern are all displaced a number of minutes in right ascension from where they should be if the Moon itself were the source. To explain these effects we may postulate that associated with the Moon there was a cloud of charged particles, several times the angular extent of the Moon, with the radio centre of the cloud situated asymmetrically with respect to the Moon, being displaced at least 1° toward smaller right ascension. It is not certain whether this cloud is itself the source of the 11-m. radiation, or whether the cloud acts as a huge reflecting surface which deflects 11-m. signals originating elsewhere, as on Venus, Jupiter or the Sun, all of which were below the horizon at the time. Although it is not clear what the primary source of the signals may be, it is convenient to refer to these radiations as 'Moon signals'.

As already reported[1], Moon reflexions were noted on June 4 and 5 of Class II signals, presumably of Venusian origin. However, as was mentioned, the observed difference in time between a direct Venusian pulse and its Moon echo was 6–10 per cent greater than the time calculated assuming the wave velocity of vacuum, and that the Moon itself was the reflecting object. If the Moon at this time had near it a large cloud of charged particles, as now seems likely, this time difference could be explained in several ways. Thus the particle cloud, acting as a conducting, dispersive medium, reduced the group velocity, or the cloud itself, displaced somewhat from the Moon but moving with it, acted as the reflecting surface, or both effects were present.

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Measurement of Ionospheric Path-Phase for Oblique Incidence

The observation of amplitudes of pulses received via various propagating modes has long been a standard technique, but observation of the corresponding carrier phases is more difficult. Several previous investigations have been made of the dynamic behaviour of the phase of the signal received in nearly vertical ionosphere reflexions, using 0·15 and 2·4 Mc./s. pulse transmissions[1]. Studies of the phase of a continuous carrier received at long ranges have been made at[2] 16 kc./s. and at[3] 5 Mc./s. Apparently, only Trautman[4], and Brennan and Phillips, of this Laboratory (private communication) have obtained results on the phase behaviour of individual oblique-incidence paths, using overlapping-pulse techniques in which the carrier phase of a given mode appears indirectly. The present communication describes three techniques, believed to be new, for direct measurement of changes of path-phase at oblique incidence, with a short sample record of each.

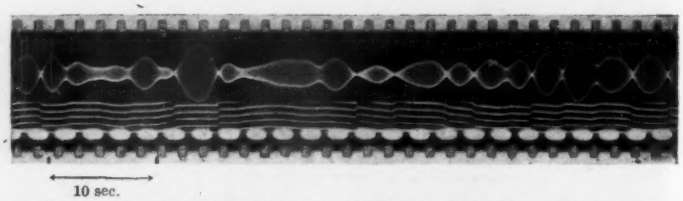


Fig. 1. 10 μsec. section of ionospheric multipath structure observed on 17·463 Mc./s. over 4,100 km. distance at 1660 E.S.T., July 21, 1955. Pulse-width about 160 μsec., repetition-rate, 200 c./s. Note strong correlation of 180°-phase discontinuities with amplitude minima. A gradual change of frequency is also evidenced by the change in slope (method I)

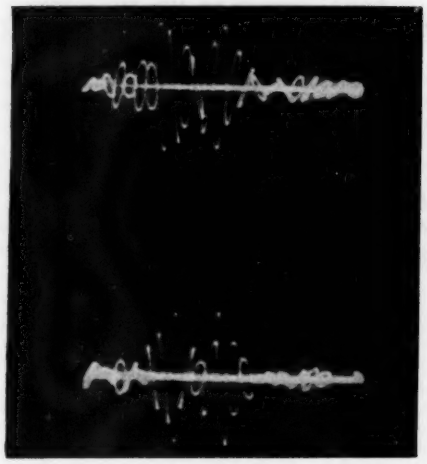
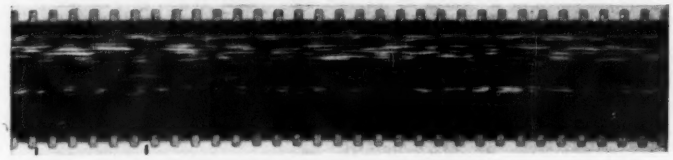
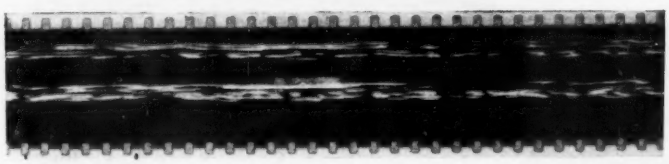


Fig. 2. Multipath structures obtained a few seconds apart (method II)



1 min.

Fig. 3. Multipath structure observed on 8·040 Mc./s. over 4,100 km. distance at 2000 E.S.T., June 25, 1956. A fairly discrete early path is followed by more or less of a continuum of paths about a millisecond later. The differences in the slope of the phase-stripe appearing simultaneously at various parts of the wave train indicate variations in the rates and directions of movement of the ionospheric layers (method III)



1 min.

Fig. 4. Multipath structures obtained simultaneously on two antennæ spaced 550 ft. apart. Observation made on 17·460 Mc./s. over 4,100 km. distance at 1340 E.S.T., June 30, 1956. Almost complete correlation between the two path structures is apparent (method III)

The essential feature common to all three techniques is the transmission of short radio-frequency pulses having a highly stable carrier-frequency and repetition-rate, together with scan-to-scan examination of one or more small sections of the undetected received wave train (multipath structure) as observed after heterodyning in an intermediate frequency that is an integral multiple of the repetition-rate. The delay of each observed section is highly stable, so that the phase changes in a mode appear as shifts of the several intermediate-frequency cycles within the corresponding section. The repetition-period is longer than the multipath duration, but shorter than the time of significant path-phase changes.

The first method yields a detailed record of the behaviour of phase and amplitude in a single section of the wave train received. A film strip is slowly moved horizontally past an oscilloscope tube the two beams of which form vertical lines, one over the other, showing amplitude and phase information, respectively. Amplitude is presented by feeding the received intermediate frequency to the vertical axis of one beam that is gated on only during the desired section (a few cycles long). Phase is presented on the other beam by intensifying at the zero crossings of the several intermediate frequency cycles occurring during a vertical sawtooth sweep across the section. Fig. 1 is a typical record, with amplitude on the top trace, phase in the middle, and timing markers at the bottom.

The second and third methods enable observation of the complete wave train both in amplitude and phase, although a given section is presented in much less detail. In the second method a number of sections about one pulse-width (160 μsec.) apart in delay are observed. For each a Lissajous pattern is generated by feeding the received intermediate frequency to the vertical axis and a reference oscillation of the same frequency to the horizontal axis of a single beam. The beam is unblanked only during each section, and lateral shifts of the beam separate the Lissajous patterns of different sections. Fig. 2 shows two records made in roughly this way.

The third method is a variation of the second to present a series of scans instead of just one. Instead of feeding the intermediate frequency to the vertical axis, it is used to give intensity modulation to the beam, and a film strip is moved past this linear display. The result is a series of stripes, the positions of each of which laterally over a small range give the phase of the corresponding section, and the intensity of which gives the amplitude.

Rates of path-phase variation observed so far correspond roughly to the amplitude fading-rate (as might be expected). With the frequency stability of the equipment used, the amount of slow drift (for example, in Fig. 1) due to ionospheric Doppler effect cannot be distinguished reliably from that associated with the stability of the crystal frequency of the equipment. Experiments beginning soon will use commercially available cæsium frequency standards and will also include the examination of multipath propagation associated with ionospheric forward scatter.

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Ultra-Violet Band Systems of HF^+ and DF^+

Although band-systems of HCl^+ and HBr^+ have been known for many years, there is no definite spectroscopic information about HF^+. Woods[1] observed a many-line spectrum in the ultra-violet region in dischargos in the presence of hydrogen fluoride vapour, and what was apparently the same spectrum was later excited by Barrow and Caunt[2], who analysed five bands of a $v' = 0$ progression. They were unable to identify the emitter with certainty, and later experiments, carried out in the hope of finding suitable conditions for the excitation of the spectrum of the deuteride, were unsuccessful.

We have now found that the ultra-violet system may be excited reproducibly in hollow-cathode discharges, in the presence of a few millimetres pressure of helium, in which the hollow cathode contains potassium bifluoride. The corresponding system of the deuteride has also been observed in discharges with KDF_2 in the cathode.

The spectra consist of a large number of lines, without apparent regularity, in the region 2100–2650 A. So far, we have assigned about 650 lines to nineteen bands in the hydride system and 300 lines to six bands in the deuteride system. Each band appears to consist of two branches, P and R. The earlier analysis of the hydride bands is confirmed, but the study of the isotope effect allows true vibrational quantum numbers to be assigned to the lower state.

The emitter of the bands is identified from the rotational and vibrational constants of the upper state, B. Agreement between the constants observed for the deuteride and those calculated from the hydride is obtained only if the ratio of reduced masses (ρ^2) has the value required for μ_{HF}/μ_{DF} ($= 0{\cdot}52555$). Values are given in Table 1.

Table 1. Constants for $B^1\Sigma^+$ of DF^+

	Observed	Calculated from hydride* (i)	(ii)
B_0	2·115	2·113	2·130$_8$
B_1	2·105	2·104	2·122
D_0	$5{\cdot}19 \times 10^{-6}$	$5{\cdot}22 \times 10^{-6}$	$5{\cdot}31 \times 10^{-6}$
D_1	$5{\cdot}48 \times 10^{-6}$	$5{\cdot}39 \times 10^{-6}$	$5{\cdot}49 \times 10^{-6}$
$\Delta G_{0,1}$	822·0	821·8	824·9

* (i) $\rho^2 = 0{\cdot}52555 = \mu(HF)/\mu(DF)$. (ii) $\rho^2 = 0{\cdot}53000 = [\mu(OH)/\mu(OD)$

Information about the lower state, A, cannot readily be summarized in equilibrium rotational and vibrational constants as anharmonic terms are large: moreover, we have information at present only on levels $v'' = 4$ to 10 in the hydride, and $v'' = 7$ to 10 in the deuteride. The extent of the departure from harmonic behaviour suggests that Dunham corrections may be important; however, a comparison of the constants so far determined shows that the simple isotope relations are at least approximately fulfilled (Table 2). A summary of the main constants for the two states of the hydride is given in Table 3.

The energy of dissociation of the lower state of the hydride may be obtained with some precision

Table 2. Constants for $A^1\Sigma^+$ of DF^+

	Observed	Calculated from hydride*
B_7	5·988	5·978
B_8	5·696	5·679
B_9	5·390	5·370
B_{10}	5·062$_8$	5·048
$\Delta G_{7,8}$	1,390·3	1,387·8
$\Delta G_{8,9}$	1,294·8	1,292·5
$\Delta G_{9,10}$	1,193·9	1,191·4

* With $\rho^2 = 0{\cdot}52555$

Table 3. Constants for $A^1\Sigma^+$, $B^1\Sigma^+$ of HF^+

$A^1\Sigma^+$
$G_v = 2{,}977{\cdot}6\,(v+\frac{1}{2}) - 111{\cdot}91\,(v+\frac{1}{2})^2 + 4{\cdot}317\,(v+\frac{1}{2})^3 - 0{\cdot}2569\,(v+\frac{1}{2})^4$
$B_v = 15{\cdot}212 - 0{\cdot}6746\,(v+\frac{1}{2}) - 0{\cdot}00106\,(v+\frac{1}{2})^2 - 2{\cdot}66 \times 10^{-7}\,(v+\frac{1}{2})^3$
$r_0 = 1{\cdot}076$ A.

$B^1\Sigma^+$
$\nu_0 = 57{,}258$ cm.$^{-1}$
$G_v = 1{,}158{\cdot}4\,(v+\frac{1}{2}) - 17{\cdot}2\,(v+\frac{1}{2})^2$
$B_v = 4{\cdot}027_7 - 0{\cdot}0216\,(v+\frac{1}{2}) - 0{\cdot}0011\,(v+\frac{1}{2})^2$
$r_0 = 2{\cdot}092$ A.

by a short extrapolation to $D' = 20{,}480$ cm.$^{-1}$. A rough value for D'_v may be obtained by linear extrapolation: this gives $D'_v = 18{,}900$ cm.$^{-1}$. With $\nu_{0,0} = 56{,}372$ cm.$^{-1}$, we find that the separation of the atomic states at infinite internuclear distance is 54,800 cm.$^{-1}$. Since the extrapolation for the upper state amounts to about 15,000 cm.$^{-1}$, we cannot expect this estimate to be very precise, but it suffices for a plausible identification of the atomic products. The excited states of the neutral fluorine atom are crowded into a region lying within about 34,000 cm.$^{-1}$ of the ionization limit, and neutral HF cannot then be the emitter. If, however, we examine the states giving rise to HF^+, we find $H^+(^1S_0) + F(^2P)$ at 0 cm.$^{-1}$, $H(^2S_{1/2}) + F^+(^3P)$ at 30,875 cm.$^{-1}$, $H(^2S_{1/2}) + F^+(^1D_2)$ at 51,748 cm.$^{-1}$ and $H(^2S_{1/2}) + F^+(^1S_0)$ at 75,794 cm.$^{-1}$ It seems highly probable that state A correlates with $H^+ + F(^2P)$, and B with $H + F^+(^1D)$. Both atom pairs give $^2\Sigma^+$ states, and this fits in with the fact that the bands appear to possess only two branches: the spin-doubling has yet to be resolved. State A is then analogous to $A^2\Sigma^+$ in HCl^+; state B to $A^2\Sigma^+$ in OH.

The ground-states of the molecules HCl^+ and HBr^+ are $^2\Pi_i$, correlating with $H + X^+(^3P)$: the analogous state in HF^+ remains to be found. Whether it lies above or below $A^2\Sigma^+$ is not yet known; many unassigned lines in the ultra-violet region remain, and a search for bands of transitions $A^2\Sigma^+ - {}^2\Delta$, $B^2\Sigma^+ - {}^2\Pi$ is now in progress. Electron-impact studies might throw light on the question of which state is the ground-state. If $A^2\Sigma^+$ is the ground-state, then the ionization potential of HF is found to be 16·88 eV.; this may be compared with the estimate, 18·23 eV., given some years ago by Mulliken[3].

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Comparison of Threshold of Hearing for Bands of Noise and for Pure Tones

The results of some measurements of the threshold of hearing for a pure tone and for a band of noise may be of general interest as they have a bearing on the resonance theory of hearing. (The connexion between such measurements and the resonance theory of hearing was pointed out by D. Boston at a meeting of the Physical Society of London in 1953.)

Comparisons were carried out on twenty-seven subjects by the free-field method in an anechoic room 24 ft. × 12 ft. × 9 ft. which contained only the subject, sitting on a chair facing the loud speaker 12 ft. away, and a microphone for measurement of the

intensity of sound. In the first experiment the thresholds of a 1,200 c./s. tone and of noise in the octave 800–1,600 c./s. were compared. If it can be assumed that the published figures for critical band-widths[1] are valid at threshold, then the cochlear 'resonator' at 1,200 c./s. has an equivalent band-width of some 50 c./s., and the ratio of threshold power for noise to threshold for a 1,200 c./s. tone should be 840/50 or 16·8, which is more than 12 decibels, whereas our results indicate a mean ratio of only 1 db., with a quartile of 2 db.

In the second experiment we attempted to produce a band of noise covering several octaves; but owing to imperfections of the speaker the equivalent width of the response, corrected according to the acuity curve given by Fletcher[2], was only 1,800 c./s. centred at 2,450 c./s. The threshold of this noise was compared with that of a 2,000 c./s. tone, which is good enough because the sensitivities of the ear at 2,000 and 2,400 c./s. are nearly equal[2]. The equivalent band-width of the 'resonator' at 2,400 c./s. is given in Beranek[1] as 80 c./s., so that ratio of threshold for the noise to threshold for the tone would be 1,800/80 or 22·5, which is 13·5 db., whereas our results gave a ratio of 2–3 db. with a quartile of 3–4 db., and less than 4 per cent of the results exceeding 13 db. Although the discrepancy between calculation and observation is not as telling as in the first experiment, it remains true that in both cases the calculated ratio is about 20 whereas the observed ratio is close to unity, at variance with a resonance theory of hearing in which thermal noise of the 'resonator' determines threshold. This conclusion would appear to be confirmed by some headphone measurements on the masking of pure tones by noise which have been carried out by Hawkins and Stevens[3]. We feel that the work should be repeated under better acoustic conditions, with more subjects, and with wide bands of noise of spectra adjusted to match the hearing curves so as to avoid preponderance of a narrow region of frequencies in fixing the threshold of the noise.

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Role of Formate in the Biosynthesis of Chlorophyll *a*

When cultures of *Chlorella vulgaris* were incubated with formate-^{14}C it could be demonstrated that the carbon atom of formate may serve as a precursor of the methyl ester carbon atom of chlorophyll *a*, without contributing extensively to the biosynthesis of the dihydroporphyrin ring. The procedure for growing *Chlorella vulgaris* as well as the preparation of methyl-phæophorbide *a* has been described[1]. However, in the place of inert acetate and glycine added previously, inert sodium formate ($2{\cdot}44 \times 10^{-3}$ *M*) as well as 8·6 mgm. (33 μc.) of sodium formate-^{14}C ($2{\cdot}1 \times 10^{7}$ c./m.) were added to the growing medium. Methyl phæophorbide *a* was converted to chlorin e_6 according to the method of Willstätter[2], and both degradation products of chlorophyll *a* were subjected to paper chromatography. Methyl phæophorbide *a* was chromatographed twice in decane/4-methyl-2-pentanone, 2 : 1 (v/v) and once in *n*-decane/1-propanol, 6 : 1 (v/v). Repeated chromatography did not significantly alter the specific activity. Chlorin e_6 was chromatographed once in the lutidine/water/ammonia system of Falk *et al.*[3]. The separated pigments were cut out and eluted with acetone and acidified acetone, respectively. Details of this chromatographic procedure will be published elsewhere. The concentration of methyl phæophorbide *a* or chlorin e_6 in the respective eluate was determined spectrophotometrically, applying the absorption coefficients reported by Holt and Jacobs[4] and Stern and Wenderlein[5]. The solvents of the eluates were evaporated and the solid material deposited as an infinitely thin layer on glass planchettes. The carbon-14 activity was then determined with a windowless methane gas-flow counter operated in the proportional region. The experimental results are shown in Table 1.

Table 1. The Incorporation of Formate-^{14}C into Chlorophyll *a* Derivatives

	^{14}C-activity*	Dilution factor†
Sodium formate-^{14}C	68·0	
Methyl phæophorbide *a*	1·6	42·0
Chlorin e_6	0·15‡	452·0

* The ^{14}C-activity is expressed in units of c.p.m. × 10^4 per mgm. carbon.
† Dilution factor = $C_s/C - 1$, where C_s = ^{14}C-activity of formate and C = ^{14}C-activity of the chlorophyll derivative isolated.
‡ The stated specific activity of chlorin e_6 is less precise than the comparable value for methyl phæophorbide *a* due to the low isotope concentration and other methodological factors.

These results indicate that approximately 90 per cent of the total carbon-14 activity incorporated into methyl phæophorbide *a* is localized in the methyl-ester carbon atom of the carboxyl group linked to the cyclopentanone ring. The dilution of the isotope concentration in this carbon atom is only about forty-fold as compared with the formate added. Since no degradation of chlorin e_6 was carried out, the distribution of the carbon-14 activity among the carbon atoms of this substance remains unknown. The results (Table 1) show that formate makes only a minor contribution to the biosynthesis of the dihydroporphyrin ring of chlorophyll.

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Nature and Site of Origin of the Hyperglycæmic Substance released following an Injection of Growth Hormone

THE presence of a hyperglycæmic substance in the blood of the pancreaticoduodenal and portal veins of animals treated with growth hormone has been reported by Bornstein, Reid and Young[1] and by Foa, Magid, Glassman and Weinstein[2]. These authors have been commendably cautious in the interpretation of their findings; but the inference that this hyperglycæmic substance is glucagon has been made by many who have discussed these papers.

Ellis, Anderson and Collins[3] have demonstrated that in rabbits, dihydroergotamine effectively blocks the hyperglycæmic effect of adrenaline but not that of glucagon (Lilly). Sirek, Sirek and Best[4] have reported that dihydroergotamine also prevents the rise in blood-sugar levels of diabetic dogs following injection of blood from the pancreaticoduodenal veins of normal dogs treated with growth hormone. Thus, this hyperglycæmic effect is attributable, in large part at least, to substances other than glucagon.

Further investigations[4] have been carried out concerning the source of the hyperglycæmic substance. To determine whether it comes exclusively from the pancreas, two completely depancreatized dogs, with intact pancreaticoduodenal veins, were used as donors. Following the administration of growth hormone, samples of blood from the pancreaticoduodenal veins produced the characteristic hyperglycæmic response in the diabetic recipients. Thus, the pancreas is certainly not the sole source of the hyperglycæmic substance.

Sutherland and de Duve[5] found a hyperglycæmic substance not only in extracts of pancreas but also in those from the gastric and intestinal mucosa of some species. They suggested that argentaffin cells in these tissues might be the source of the hyperglycæmic substance, which they did not attempt to characterize chemically. In 1952, Erspamer and Asero[6] identified the 'enteramine' in the argentaffin cells of the gastrointestinal tract as 5-hydroxytryptamine ('Serotonin'). Various pharmacological effects of this sympathomimetic substance are blocked by dihydroergotamine even more effectively than are those of adrenaline[7].

We were thus led to consider the possibility that the hyperglycæmic substance demonstrable in the blood of the pancreaticoduodenal vein following an injection of growth hormone might be 5-hydroxytryptamine, released from the enterochromaffin or other cells of the gastrointestinal tract. No mention of any hyperglycæmic action of this compound in physiological doses has been found in the literature. Hyperglycæmic responses were obtained by Correll, Lyth, Long and Vanderpoel[8] with very large and certainly unphysiological amounts (10 mgm. of 'Serotonin' creatinine sulphate per kgm. body-weight in rats). On the other hand, Weitzel, Roester, Buddecke and Strecker[9] were unable to produce a consistent rise in blood sugar in rabbits with 20–500 gamma of 'Serotonin' creatinine sulphate per kgm. body-weight. We have injected 0·12 mgm. of 'Serotonin' creatinine sulphate into each of two normal dogs weighing 11·0 kgm. No hyperglycæmia resulted. When the same, or even half, the amount of 'Serotonin' was injected into each of two depancreatized dogs weighing 8·5 and 7·5 kgm. respectively, however, there was a significant

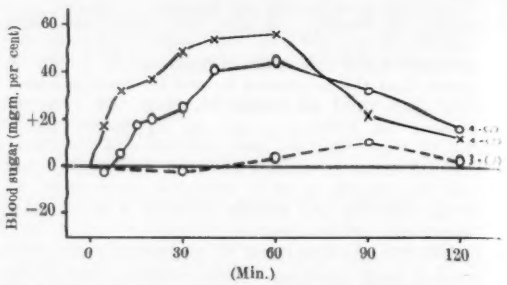

Fig. 1. O——O, 5-Hydroxytryptamine to diabetic dog; O - - - O, 5-hydroxytryptamine to normal dog; ×——×, portal blood from normal donor treated with growth-hormone into diabetic recipient. *x—(y)*: *x represents number of experiments*; *y represents* number of animals

rise in blood-sugar levels during the first 40–60 min. The same results were obtained when the tests were repeated two weeks later. The average changes in blood-sugar levels following injections of 5-hydroxytryptamine are shown in Fig. 1, where it can be seen that they closely resemble those obtained following injection of portal blood from normal dogs treated with growth hormone. There is, of course, no evidence as yet that the hyperglycæmic material which appears in the blood of the depancreatized dogs is 5-hydroxytryptamine; but the demonstration that this latter substance produces a similar type of rise in blood-sugar in these animals encourages an exploration of this possibility.

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Metabolism of *dl*-Ornithine-2-^{14}C in Normal and Potassium-deficient Barley

WHILE it has been known for many years that potassium is concerned in some way with the protein metabolism of plants, knowledge of the part played by this element is fragmentary. Richards and Coleman[1,2] have shown that putrescine is accumulated characteristically in potassium-deficient barley and that certain well-known deficiency symptoms are a direct consequence of the presence of this amine. The accumulation of putrescine in association with potassium starvation points to a specific function of this element in the nitrogen metabolism of barley. The present communication directs attention to the fact that ornithine-2-^{14}C is readily metabolized by barley and white clover, resulting in the formation of some structurally related amino-acids, and that in potassium-deficient barley, an additional substance, a decarboxylation product, putrescine, results.

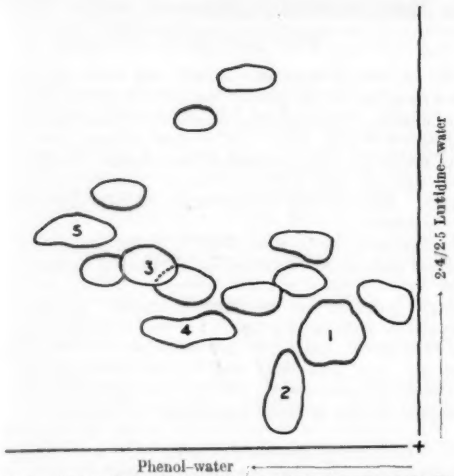

Fig. 1. Autoradiograph, taken from a chromatogram of the free amino-acids of potassium-deficient barley which had received *dl*-ornithine-2-^{14}C, showing the position of putrescine (2) in relation to ornithine (1), citrulline (3), arginine (4) and proline (5)

Further, some effects of the metabolism of radioactive citrulline and arginine are given.

A series of experiments was performed using paper chromatography and radioactive chemicals to follow metabolic processes as they occur in the living tissue. The plants were grown in water culture and amino-acids labelled with carbon-14 were introduced by feeding techniques developed by Coleman and Richards[2]. The amino-acids were presented through cut stems for periods not exceeding 2 hr.; the plants were then transferred to distilled water for periods of from 4 to 21 hr. to allow metabolism to proceed. The amino-acid content of the plants at the end of the 2-hr. feeding periods was compared with that present at the conclusion of the experiments. That no significant bacterial activity occurred in the feeding solutions during the feeding period (2 hr.) was shown by the absence of metabolic breakdown products.

Fig. 1 presents, diagrammatically, an autoradiograph prepared from an extract of potassium-deficient barley which had received *dl*-ornithine-2-^{14}C. The total metabolic process occupied 23 hr. (The ornithine, free of radioactive impurities, was obtained from Tracerlab Inc., U.S.A.) Autoradiographs of normal, healthy barley and white clover plants similarly treated (total period of feeding experiment, 6 hr.) had well-defined spots of citrulline, arginine and proline, as well as smaller amounts of glutamic acid, γ-aminobutyric acid and glutamine. (Some of these amino-acids are among the unnumbered substances occurring in the potassium-deficient plants of Fig. 1.) Ornithine has not been detected in many well-known species of higher plants, though it is known to occur in *Alnus* spp.[3] and *Asplenium nidus*[4]. However, the conversion of this amino-acid into citrulline, arginine and proline in barley and white clover, as shown by these experiments, does suggest that it is a normal metabolite at least in these plants.

The occurrence of radioactive putrescine in potassium-deficient barley containing *dl*-ornithine-2-^{14}C suggests that a decarboxylating mechanism operates, at least where potassium is in short supply. Putrescine arises in *Bacterium coli* by enzymatic decarboxylation of ornithine[5] and its occurrence in barley might well result through the operation of such a mechanism. Beevers[6] has shown that barley roots contain the enzyme glutamic acid decarboxylase, which can convert glutamic acid to γ-aminobutyric acid. However, while the substances putrescine, tyramine and β-alanine (decarboxylation products of ornithine, tyrosine and aspartic acid, respectively) are found in barley, there is at present no evidence of specific enzymes occurring in this plant which decarboxylate these amino-acids. Further work is needed to understand the mechanism of ornithine decarboxylation in potassium-deficient barley.

The ornithine-feeding experiments suggest that many of the enzymes of the Krebs–Henseleit amino-acid cycle are present in barley and white clover, and that they may have a place in the nitrogen metabolism of these and other plants. It would appear that the formation of arginine from ornithine proceeds through citrulline. Evidence of the step from citrulline to arginine was earlier demonstrated by one of us (R. G. C.; Ph.D. thesis, 1953, University of London), when it was shown that normal barley plants accumulated arginine when fed with L-citrulline. This fact has now been verified by feeding L-citrulline-^{14}C, labelled in the carbamyl position[7], to both barley and white clover. In both cases moderate amounts of radioactive arginine and traces of urea were formed, and, apart from the presence of a trace of an unidentified substance, no other labelled substances were detected. Enzymes which may convert arginine to ornithine are also apparently operative, since plants given L-arginine-^{14}C, uniformly labelled, contained active citrulline and proline. Ornithine was not detected on the autoradiographs; but as this amino-acid is rapidly converted in the plant cells to citrulline and proline, its accumulation would not be expected. A large amount of radioactive proline was found in the normal plants receiving ornithine-2-^{14}C. This close association of proline with ornithine metabolism points to a pathway of proline formation from ornithine in higher plants, presumably via glutamic γ-semialdehyde and Δ^1-pyrroline-5-carboxylate, a metabolic process known to operate in *Neurospora crassa*[8].

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Self-Alkylation of some Dialkyl Phosphate Esters

The alkylation of tertiary amines by neutral phosphate esters has been reported[1], and in one instance self-methylation has been observed[2]. Thus, Andrews *et al.* found that (*m*-dimethyl phosphato)-N-dimethylaniline forms the quaternary zwitterion slowly at room temperature and rapidly on heating. Hobbiger[3] found that the anticholinesterase activity of the dimethyl, diethyl and di-*iso*propyl ternary

compounds increased in water, which suggests that (dialkyl phosphato)-N-dimethylalkylanilinium compounds are formed by the bimolecular reaction :

$$2\ NMe_2.C_6H_4—m—OPO(OR)_2 \rightarrow \overset{+}{N}Me_2(R).C_6H_4—m—OPO(OR)_2 + NMe_2.C_6H_4—m—\overset{-}{O}PO_2.OR$$

The dialkyl quaternary compounds are powerful inhibitors of cholinesterase[4], whereas it is unlikely that the zwitterion is.

I have found that similar reactions take place when O,O-dimethyl and O,O-diethyl S-ethylthioethyl phosphorothiolates are stored either alone or in water. In these reactions the acceptor atoms are binary sulphurs.

The O,O-dimethyl compound, $(MeO)_2PO.SCH_2CH_2.SEt$, decomposes in water and dilute acids with a half-life of 10·7 days at 37°. Hydrolysis can give only phosphoric acids, which are anions in neutral solution. In fact, cations are also formed. Thus a 1 per cent solution was left at room temperature for fourteen days. The parent compound was then removed by extracting with chloroform and the aqueous layer concentrated *in vacuo* at less than 20° and subjected to paper electrophoresis at *p*H 5·3. The paper was cut up, and the fractions eluted and assayed for phosphorus. Three bands were found : a band of anions containing 68·4 per cent of the phosphorus ; a neutral band containing 11·6 per cent ; and a cationic band containing 20·0 per cent. The cationic band was characterized by very powerful anticholinesterase activity.

The cation was identified as O,O-dimethyl S-ethylsulphonioethylmethyl phosphorothiolate, formed by the second-order reaction :

$$2\ (MeO)_2PO.SCH_2CH_2.SEt \rightarrow \overset{-}{M}eOPO_2.SCH_2CH_2.SEt + (MeO)_2PO.SCH_2CH_2.\overset{+}{S}(Me)(Et)$$

The identification rests on the following considerations, which will be dealt with more fully elsewhere. The product is formed by a second-order reaction with respect to the parent compound, and it is positively charged. Cholinesterase inhibited by a short period of contact with it recovers its activity at the rate typical of the dimethyl-phosphorylated enzyme[5], and a compound of very similar properties is produced by the reaction of the parent compound and methyl iodide in ethanol under mild conditions (see Table 1). The proposed structure explains the high anticholinesterase activity of the compound, as it is similar to that of acetylcholine. The alternative structure, in which the other sulphur is methylated, does not explain the high activity.

Table 1. Some Properties of O,O-Dimethyl S-Ethylsulphonioethylmethyl Phosphorothiolate

	A	*B*
Rate constant for decomposition in *N*/200 hydrochloric acid at 37° (10^5 k. min.)*	4·05 ± 0·44	3·66 ± 0·11
$10^6 I_{50}$ molar†	3·75	3·95

A : prepared by the action of water on the parent compound.

B : prepared by methylation with methyl iodide.

* Determined by the rate of decrease of cholinesterase activity. The rates were first-order ; the errors indicated are the standard errors.

† Determined using sheep erythrocytes as a source of cholinesterase.

The uncharged compound may be the zwitterion, which can, in theory, be formed by the analogous first-order reaction :

$$(MeO)_2PO.SCH_2CH_2.SEt \rightarrow \overset{-}{M}eOPO_2.SCH_2CH_2.\overset{+}{S}(Me)(Et)$$

By electrophoresis the cation has been separated from samples of the parent compound stored at room temperature. One sample, stored for about two years, contained 4 per cent. A similar cation has been obtained from the O,O-diethyl homologue ('Isosystox') after storage and after leaving in water for several weeks. The diethyl compound alkylates itself relatively slowly.

It appears likely that dialkyl phosphate esters in general should be regarded as alkylating agents, and that, should they contain acceptor atoms, such as binary sulphur or ternary nitrogen, some self-alkylation will take place. In the examples given, self-alkylation leads to increased anticholinesterase activity, but this may well be exceptional, as the increase is presumably due to the positions of the acceptor atoms in these particular molecules.

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Column Chromatography of Anthocyanins

In our laboratory we have been endeavouring to devise a simple technique for chromatographic separation of anthocyanins[1-3]. Various partition media, mainly several kinds of cellulose powder, namely, Tōyō, Carl Schleicher and Schüll No. 123 and Whatman *B* and Ashless were used. It was found that the quality of the cellulose powder was one of the most important factors, and that only Whatman *B* (produced between 1952 and 1953 according to a letter from H. Reeve Angel and Co., London) showed excellent separating ability.

Fig. 1. Column chromatographic separation of anthocyanins extracted from *Viola tricolor maxima*. Three hours after introduction of the solvent, six colour bands were apparent

The experimental procedure was as follows. The cellulose powder was placed with about five times as much water in a glass tube (35 cm. in length and 4 cm. in inside diameter, equipped with a glass filter and a stopcock at the bottom), filling it up to the rim. Then the loosely packed powder column was compressed by a rubber stopper in order to remove the excess water and left to stand overnight to free it from air bubbles. Next, with the help of a circular filter paper, the column was irrigated with about half a litre of the aqueous phase of the solvent mixture, butanol/36 per cent hydrochloric acid/water (5 : 1 : 4,

v/v). Before the irrigation was completed, about 15 c.c. of crude extract of anthocyanins, for example, from *Viola tricolor maxima*, was pipetted into the column, and chromatographed with half a litre of the organic phase of the solvent mixture.

By this procedure, the anthocyanin mixture was separated into a well-developed chromatogram, as shown in Fig. 1. Then the column was pushed out and cut into bands, and the anthocyanins were eluted with methanol. The methanolic solutions were concentrated, and twice as much benzene was added to obtain an aqueous anthocyanin solution or the crude crystals. They were chromatographed again by the same procedure. In this way, very pure anthocyanins were obtained; for example, violanin and keracyanin from *Viola tricolor maxima*[4]; four other anthocyanins from this plant were not determined on account of their small volume.

Unfortunately, a new batch of Whatman *B* cellulose powder made in 1956 was not so effective. Though the cause is obscure, it is assumed that the separating power of cellulose powders in partition chromatography is conditioned in the same way as that of the adsorbents in adsorption chromatography.

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Dialysis of Small Specimens in Batches

In experiments involving the separation of proteins, it is often necessary to dialyse large numbers of samples, each of a small volume. (Salt fractionation of enzymes, when the fractions cannot be assayed for enzymatic activity in presence of the salt, is a case in point.) Dialysis becomes tedious if large numbers of 1- or 2-ml. samples have to be transferred to dialysis bags from the centrifuge tubes used for precipitating and centrifuging down the fractions, and then have to be recovered more or less quantitatively.

The simple apparatus illustrated in Fig. 1 has proved satisfactory. The rotor consists of a funnel-shaped test tube rack made of polyethylene, with radial ridges which hold the tubes between them. According to the size of the rotor 12–24 tubes can be accommodated at a time.

The tubes containing the samples are covered at the mouths with dialysing membranes, which are secured with small rubber bands. The tubes are checked for leakage by chilling them for a moment, when the membranes should at once contract. The tubes are then inserted between the ridges of the rotor and kept in place by two large rubber bands surrounding the rotor which rest in deep grooves in the ridges. The rotor is then attached by a stainless steel rod to a slow-geared motor and inserted into the bath as shown in Fig. 1. Each tube will then turn along a conical path and thus perform a combined revolving and shaking movement. A rate of 15–25 rotations per min. has been found to provide efficient stirring without causing much foaming. The apparatus also allows dialysis of suspensions, as

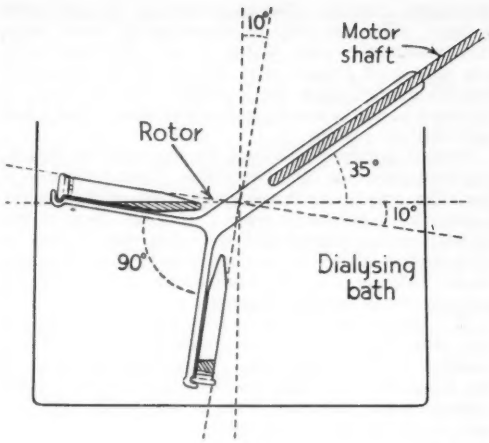

Fig. 1

clogging of the membrane by accumulating particles is avoided.

Using this apparatus, the dialysis of a 1-ml. specimen from a 15-ml. centrifuge tube takes about two to three times as long as dialysing from a bag by the usual method. This disadvantage is, however, for most purposes more than outweighed by the simplified manipulation.

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L Forms of Bacteria and their Role in the Origin of Penicillin Resistance

Investigation of the penicillin resistance of the secondary rods regenerated within the complete or incomplete *L*-cycle is of a great importance for understanding the biological significance of *L* forms of bacteria. So far, only a few authors have occupied themselves with this problem[1–5]. There is one group of authors who maintain that the secondary rods are more resistant to penicillin than the primary ones[5]; on the other hand, there are far more workers who are of the exactly opposite opinion[1–3]. In 1954, we carried out preliminary experiments with *Proteus vulgaris*[6]. It appeared that the secondary rods do not differ essentially from the primary ones with regard to penicillin resistance. These results were confirmed by the following experiments: (1) determination of resistance of the secondary rods regenerated from one large body; (2) determination of the amount of penicillin in broth culture in the time of regeneration of the bacillary form.

(1) Large bodies were isolated from the broth culture containing 1,000 units of penicillin/ml. by the Lindner drop method and the regeneration of the rods was observed in the phase contrast microscope in the moist chamber. The resistance of these rods to penicillin was established by the dilution method in the Lahelle modification[7]. The results were read after 5–7 days and the resistance averaged between

500–2,000 units/ml. This high value is obtained after 5 days. The majority of investigators have taken their readings usually within 24 hr. We found with our strains of *Proteus* that the result of titration is stabilized only after the duration of some days of incubation, and it is only in this way that we achieved reproducible results.

From a hundred isolations we succeeded in obtaining secondary rods fifty-two times. Their resistance to penicillin was in accordance with that of the control culture in thirty-seven cases; in three cases it was higher (by one degree) and in twelve cases lower. In all instances which did not conform to these results a slight difference in the inoculation dose (technical failure) was *a priori* registered.

(2) The amount of penicillin was established by our own modification[8] of Pešek's linear diffusion method[9] or iodometrically. First, the influence of the temperature on the inactivation of penicillin was systematically observed both in the broth (*p*H 7·2) and in the physiological solution (*p*H 5·5) (Fig. 1). Then the amount of penicillin was subjected to further observation in regular intervals in the broth with 5,000 units/ml. inoculated with 18-hr.-old culture of *Proteus vulgaris*. Already in the first 9 hr. a rapid decrease down to 100 units was registered; in the following 3 hr. a decrease down even to 3 units was observed. After 24 hr. the amount of penicillin was lowered to as little as 0·03 units/ml. (Fig. 2).

It is interesting to note that the regeneration of the secondary rods took place in only about 24 hr., that is, 12 hr. after the decrease of penicillin to practically zero value. We take it for granted that the regeneration would take place essentially earlier if the secondary rods were more resistant than the primary ones. The rapid decrease of the amount of penicillin in the culture is not to be accounted for by influence of temperature as is apparent from the comparison of Figs. 1 and 2. The penicillin seems thus to be strongly disintegrated by the large bodies.

In comparing these results with the preceding ones we might conclude that it is the secondary rods which are more sensitive to penicillin than the primary ones, the resistance of the latter averaging between 500–2,000 units/ml.; but this discord is fictitious. It is necessary to realize that the determination of the sensitivity (eventually resistance) of the secondary culture was carried out simultaneously with that of the control culture (under the same experimental conditions). If the results corresponded with each other it proves the equal sensitivity of the primary and the secondary rods.

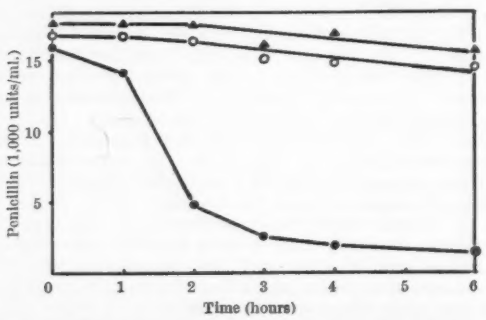

Fig. 1. The rate of decay of penicillin in 0·9 per cent salt solution (uninoculated) according to temperature. ▲——▲, 4° C.; ○——○, 22° C.; ●——●, 37° C.

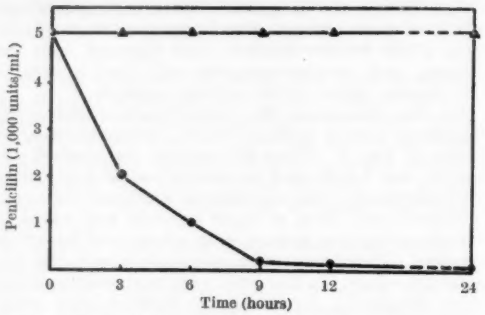

Fig. 2. The rate of decay of penicillin in broth culture of *Proteus vulgaris* at 37° C., ●——●. Control (sterile broth with 5,000 units of penicillin/ml. at 37° C.), ▲——▲

On the basis of these experimental results, we have come to the following conclusions: (1) No special significance can be attributed to the *L* forms in relation to the origin of the resistant strains of bacteria. (2) The regeneration of the secondary rods begins after a certain latent period, the amount of penicillin being reduced to a very low value 12 hr. before.

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Spore Formation in *Pellia epiphylla*

Although *Pellia epiphylla* (L.) Corda is frequently studied as an example of a liverwort, details of its mode of spore formation do not appear to be widely known. Many text-book descriptions of the process are inadequate, despite the comprehensive account of Hofmeister[1] and the fact that several interesting features of spore development can be readily demonstrated by examination of sporophytes at appropriate stages.

After fertilization[2], which usually occurs during May–July, development of the sporophyte is fairly rapid until the autumn, by which time the spore mother cells have undergone meiotic division, forming markedly four-lobed tetrads. The four-lobed character of the spore tetrads may be easily shown by the extrusion of the contents of a capsule from material collected in late autumn. At this time the spherical head of the sporogonium is usually less than 1 mm. in diameter and is still completely enveloped by the calyptra. The elaters are forming, but little trace of their spiral thickenings is as yet evident. Subsequent to nuclear division within the spore mother cell[3], thin walls develop inwards between its lobes, delimiting the spores. The wall of the spore mother cell thickens considerably in the regions where the four spores are in close contact with each other; elsewhere, the somewhat mucilaginous spore mother

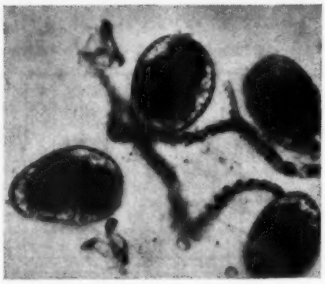

Fig. 1. Photomicrograph of spores and elaters of *Pellia* together with the remains of two mother cells from which the spores have escaped. (× 205)

cell wall is very thin, especially at the extremities of the lobes. Ultimately these thin parts of the wall rupture and dissolve, liberating the spores, which are enclosed within their own walls. The thickened regions of the spore mother cell walls form a lattice of six bands, probably mainly of cellulose, and remain for a time among the spores and elaters; they have a distinctive appearance (Fig. 1). Such structures[1] may be easily found in capsules between January and early March, but are not evident when the sporogonium is mature. The spores may begin to develop while still attached to the remains of the spore mother cells but soon become free from the latter, cell division continuing; by the time of dispersal from the capsule each ovoid spore consists usually of 6–9 cells[4]. In spring the seta elongates very rapidly and the characteristically thickened capsule wall splits into four valves exposing a mass of green spores, spirally thickened elaters and a basal elaterophore.

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Sickle Cell Gene in Indonesia

More than four thousand samples of blood from different islands in Indonesia have been examined during a mass survey on pathological hæmoglobins. The method used was the paper electrophoretic method described by Smith and Conley[1] using veronal buffer *p*H 8·6 and ionic strength 0·05 or 0·06. Several types of pathological hæmoglobins have been found; among others, hæmoglobin *E* and hæmoglobin *S*. This communication describes the discovery of the sickling gene which has hitherto not been found in Indonesia.

Two sickle cell trait carriers were found during this survey. Both showed a positive test with 2 per cent sodium meta-bisulphite.

The first carrier was born in west Java. His father was also born in west Java and was of mixed Chinese–Indonesian blood. His mother was a pure west Javanese. So far as they knew, no mixing of blood with other races took place in their ancestry. The clinical and hæmatological findings of this case have been reported elsewhere[2].

The second carrier was an Indonesian soldier from Padang (Sumatra). So far as he knew, he was a pure Indonesian. He felt healthy.

Most research workers are of the opinion that the sickling gene is a sign of some linkage to the Negro population or to their ancestry. The finding of the sickling gene in Greeks, Italians and Arabs was associated with an admixture with African blood in older times. Lehmann and Cutbush[3], however, also found the sickling trait in South India together with a low incidence of the chromosome Rho. They are of the opinion that their findings lend support to the idea of an Indian migration to Africa in prehistoric times.

The finding of the sickle cell gene in Indonesia is difficult to evaluate. Of course, one can speculate on the significance of this finding. There is a possibility that these persons had a Negro or Arab ancestor although this was denied by the people concerned. Another possibility, which is more important, is that somewhere in Indonesia or in more localized areas in this country the sickling gene is not rare and that one or other ancestor of the above-mentioned sickle cell trait carriers had some connexion with such an area. Most anthropologists are of the opinion that the oldest population of Indonesia were the Negritos[4–6], who were related to the Negroes of Africa. It is generally believed that there are areas in Indonesia, mainly in the eastern parts of the country, where impure remains of the Negritos are still present. In these areas the sickle cell gene might be found more often. However, Lehmann and Ikin[7] did not find the sickling trait in Andamese Negritos on the Andaman Islands (India), but the number of persons examined was not large. Steps are therefore being taken to explore especially those areas where the Negrito elements are supposed to be present.

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Learning and Daily Activity in a Sandhopper

In the case of the amphipod sandhopper *Talorchestia quoyana* (Milne-Edwards) it seems from some experiments that diurnal changes in light stimuli act as triggering and reinforcing factors; but there is also a conservative timing mechanism or 'memory' factor (the word is used in this sense) potent for up to a week which will maintain an impressed rhythm of activity in the absence of conflicting environmental change.

In his work on woodlice and millipedes Cloudsley-Thompson[1] observed that light and temperature were dominating factors governing diurnal rhythms of activity. Henkes[2], on the other hand, found that, while migratory pigment of the crustacean eye shows

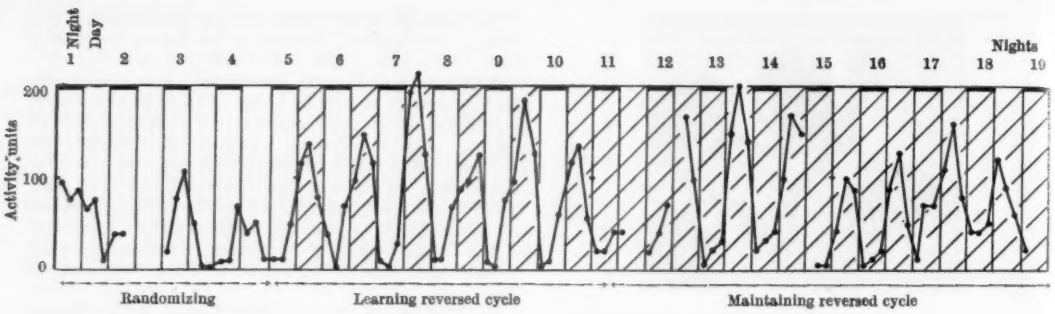

Fig. 1. Activity record. Darkness, shaded; light, plain

a similar periodicity, it is not influenced by the lighting conditions: it should be noticed that Henkes's experiments were of short duration. A discussion of the matter was given by Park[3], who found some cases of applied periodicity and others where a 'deep-seated physiological rhythm' was involved.

Talorchestia, which burrows in the supra-littoral fringe of New Zealand sand beaches, remains below ground by day and forages on the shore at night. As one of us was engaged in a biological examination of the species[4] it was decided to investigate the status of its daily rhythm. An 'Aktograph' device was employed with the temperature regulated to $12 \pm 1°$ C. and a relative humidity of 100 per cent: algal food was provided in excess throughout the experiment. The animals burrowed in a radially partitioned annulus of damp sand which surrounded a silk platform sensitive to the weight of a single specimen. Activity was recorded on a drum, and was expressed on the basis of displacement counts per unit time: electric lighting was controlled by a time switch.

In a preliminary experiment with natural lighting it was established that there is nocturnal activity which reaches its peak at midnight, and fades to almost no activity by day.

A fresh collection of animals was placed in the instrument, and after an initial week of continuous preparatory illumination, was subjected to various lighting conditions over a period of eighteen days. The recordings were divided into three phases.

For the first four days the lighting remained constant, so that the extent to which the activity had been randomized throughout the 24-hr. period could be assessed. It will be noticed (Figs. 1, 2) that, although some irregular periodicity remained, a large measure of disruption had been obtained.

Following this randomizing phase a reversed cycle of lighting was applied for six days: the animals were subjected to light at night and darkness by day in an effort to produce a reversal of activity. Here there was an almost immediate change to very low night activity and high day activity.

In the final phase continuous darkness was applied for eight days to see if this artificial activity would be maintained. From the figures it can be seen that the reversed cycle was maintained with a drift towards the random level at the end of the period.

It is suggested that here the presence of light is the factor which governs activity, and hence gives rise to the periodicity in Nature, but that this is stabilized by a 'memory' factor of at least one week's duration, as was shown by the reversed cycle, learned in the second period, and maintained in the absence of stimuli.

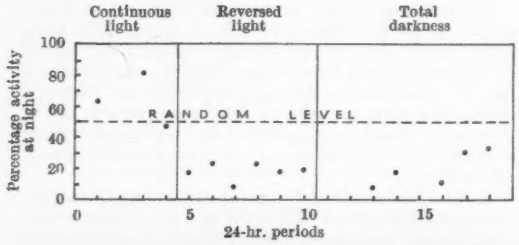

Fig. 2. Activity analysis. Note: Four values are omitted due to recording breaks

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[1] Cloudsley-Thompson, J. L., *J. Exp. Biol.*, **28**, 165 (1951); **29**, 295 (1952).
[2] Henkes, H. E., *J. Exp. Biol.*, **29**, 178 (1952).
[3] Park, O., *Ecol. Monogr.*, **10**, 485 (1940).
[4] MacIntyre, R. J., M.Sc. thesis in zoology, Canterbury University College, New Zealand (1954).

Salmonella vejle and *S. saint paul*

With reference to a communication in *Nature* of September 29, 1956, p. 702, we agree that the occurrence of *Salmonella vejle* and *S. saint paul* has apparently not been previously reported from South Africa. However, hitherto unpublished material from the South African Institute for Medical Research shows that both these organisms have been isolated from human sources in South Africa on several occasions in the past.

Approximately two thousand salmonellas have been investigated at the Salmonella Identification Unit of this Institute in the past three years. Five of these have been classified as *S. vejle* and nine as *S. saint paul*, both types appearing for the first time in February 1955.

L. Schrire
V. Bokkenheuser

South African Institute for Medical Research,
Johannesburg.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 18

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Impact of Radioactive Isotopes on the Utilization Field", opened by Dr. Denis Taylor.

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. R. C. Rainey: "The Use of Insecticides Against the Desert Locust".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. T. S. Work: "A Biochemical Approach to the Problems of Protein Synthesis".* (Further lecture on February 25.)

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. D. W. Durrant, Mr. C. Dykes Brown and Mr. J. M. Waldram: "Modern Lighting". (First of three Cantor Lectures. Further lectures on February 25 and March 4.)

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Dr. G. L. J. Bailey, Mr. W. Marchand and Mr. C. J. Thwaites: "Soldering of Metallic Coatings".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. H. W. Tilman: "Crossing the Patagonian Ice Cap".

Tuesday, February 19

IMPERIAL COLLEGE (in the Main Chemistry Lecture Theatre, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. W. K. Hayman, F.R.S.: "Pure Mathematics at a Technological University" (Inaugural Lecture).

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. A. L. Greenbaum: "The Control of Fat Metabolism".* (Twelfth of fifteen lectures of "The Scientific Basis of Medicine", organized by the British Postgraduate Medical Federation.)

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "Should Mathematics be a Compulsory Examination Subject in National Certificate Schemes?"

Tuesday, February 19—Thursday, February 21

INSTITUTION OF MECHANICAL ENGINEERS (at Central Hall, Westminster, London, S.W.1)—Conference on "The Mechanical Engineer's Contribution to Clean Air".

Wednesday, February 20

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. F. Courtney Harwood: "Modern Detergents".

PHYSICAL SOCIETY, COLOUR GROUP (in the Lecture Theatre of the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Mr. M. H. Wilson: "Goethe's Experiments on Colour"; Dr. R. A. Weale: "Trichromatic Ideas in the Seventeenth and Eighteenth Centuries".

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (in the Conference Room, 4th Floor, Waterloo Bridge House, London, S.E.1), at 5 p.m.—Mr. J. A. Lawrence, Mr. G. S. Gregson and Mr. F. L. N. Samuels: "Electronic Circuitry—Are Diagrams Really Essential?"

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. G. Horsnell: "Economical Acceptance Sampling Schemes".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. R. J. King: "Investigations of Mouse Ascites Cells by Ultra-Violet, Phase-Contrast and Interference Microscopy".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. P. W. Heselgrave: "Theory and Practice in Potential Measurements for Cathodic Protection".

Thursday, February 21

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "Work-hardening and Fatigue of Metals", opened by Prof. N. F. Mott, F.R.S.

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. M. Mary Douglas: "Co-Wives and Co-Husbands: some Political Aspects of Polygamy and Polyandry".*

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at 14 Belgrave Square, London, S.W.1), at 2.15 p.m.—Papers on "Continuous Fermentations".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4 p.m.—Symposium on "Aerobiology". Speakers: Mr. H. A. Hyde, Dr. J. M. Hirst, Dr. R. C. Rainey and Mr. L. R. Taylor.

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. K. E. Mackay and Mr. J. D. Johnson: "The Development of the Bancroft Mine"; and Mr. A. M. Bensusan: "Notes on Muscovite Mining in Southern Rhodesia".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 5 p.m.—Dr. F. C. Harper: "The Effect of Calcination Temperature on the Properties of Magnesium Oxide for use in Magnesium Oxychloride Cements".

CHADWICK TRUST (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 5.30 p.m.—Mr. Mark Hartland Thomas: "The Advantages of Modular Co-ordination in Building, with the object of Increasing Speed and Reducing Cost"* (Bossom Gift Lecture).

INSTITUTION OF CHEMICAL ENGINEERS (in conjunction with the BRITISH NUCLEAR ENERGY CONFERENCE, at the Royal Institution, Albemarle Street, London, W.1), at 5.30 p.m.—Mr. R. Spence and Mr. C. M. Nicholls: "The Processing of Nuclear Reactor Fuels".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Honor B. Fell: "The Physiology of Skeletal Tissue in Culture".* (Thirteenth of fifteen lectures on "The Scientific Basis of Medicine", organized by the British Postgraduate Medical Federation.)

SCIENTIFIC FILM ASSOCIATION (in the Mezzanine Cinema, Shell-Mex House, Strand, London, W.C.2), at 6.30 p.m.—Meeting on "Films and Automation"; Principal Speaker: Mr. S. B. Bailey.

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. W. S. S. Ladell: "Some Physiological Aspects of the Heat Disorders".

Friday, February 22

ASSOCIATION OF APPLIED BIOLOGISTS and the HORTICULTURAL EDUCATION ASSOCIATION (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, South Kensington, London, S.W.7), at 10.45 a.m.—Joint Symposium on "The Influence of Light on Plant Growth".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Geophysical Discussion on "The Influence of the Sun on the Ionosphere". Chairman: Mr. J. A. Ratcliffe, F.R.S.; Speakers: Prof. C. W. Allen, Dr. W. J. G. Beynon, Dr. M. A. Ellison, Mr. C. M. Minnis, Mr. M. Ryle, F.R.S., and Dr. K. Weekes.

Saturday, February 23

BIOCHEMICAL SOCIETY (in the Beveridge Hall of the Senate House, University of London, W.C.1), at 11 a.m.—Symposium on "The Structure and Function of Subcellular Components".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. K. E. Larsson (Gothenburg): "A Swedish Fishing Community".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN PURE MATHEMATICS; and a LECTURER IN APPLIED MATHEMATICS—The Registrar, University College of North Staffordshire, Keele, Staffs (February 20).

HEAD (with high qualifications in chemistry and experience in both teaching and research) OF THE DEPARTMENT OF CHEMISTRY—The Principal, Chelsea Polytechnic, London, S.W.3 (February 23).

LECTURER (with a degree in pharmacy, physiology or pharmacology) TO TEACH PHYSIOLOGY AND PHARMACOLOGY; and a LECTURER (with a degree in mathematics and teaching experience) IN THE MATHEMATICS DEPARTMENT—The Registrar, The Technical College, Sunderland, Co. Durham (February 23).

READER IN MECHANICAL ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 7).

SENIOR LECTURER IN EDUCATION at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Cape Town, March 7).

ASSISTANT LECTURER IN SOIL SCIENCE IN THE DEPARTMENT OF AGRICULTURAL CHEMISTRY—The Registrar, University College of Wales, Aberystwyth (March 9).

LECTURER IN ELECTRICAL ENGINEERING—The Registrar, The University, Sheffield (March 9).

LEVERHULME POSTGRADUATE FELLOWS (two in the Faculty of Science and one in the Faculty of Engineering)—The Registrar, The University, Liverpool (March 9).

LECTURER or ASSISTANT LECTURER IN PHARMACOLOGY at the University College of the West Indies—The Secretary, Senate Committee on Colonial Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (March 11).

READER IN CHEMICAL PATHOLOGY at King's College Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 12).

HEAD (Senior Principal Scientific Officer grade) OF THE DEPARTMENT OF SOIL MICROBIOLOGY—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (March 14).

ASSISTANT (with an honours degree in agricultural biochemistry, agricultural chemistry, biochemistry or chemistry, and interested in animal nutrition) IN AGRICULTURAL BIOCHEMISTRY—The Secretary, The University, Aberdeen (March 15).

LECTURER IN THEORETICAL CHEMISTRY—The Registrar, The University, Bristol (March 15).

LECTURER or ASSISTANT PROFESSOR (with a Ph.D. degree in mathematics or in mathematical statistics)—The Chairman, Mathematics Department, McMaster University, Hamilton, Ontario, Canada (March 15).

LECTURER (with a good honours degree) IN CHEMICAL ENGINEERING—The Registrar, King's College, Strand, London, W.C.2 (March 16).

RESEARCH FELLOW IN MATHEMATICS; and ASSISTANTS IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (March 25).

LECTURER IN AERODYNAMICS—The Secretary of University Court, The University, Glasgow (March 30).

LECTURER or SENIOR LECTURER IN INORGANIC CHEMISTRY at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, March 31).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY, PHYSICS and allied subjects, for example, PHARMACOLOGY, ENGINEERING, METALLURGY—The Registrar, The University, Manchester 13 (April 30).

TURNER AND NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS, and allied subjects—The Registrar, The University, Manchester 13 (April 30).

ASSISTANT CHEMIST (with a degree or equivalent qualification, and preferably with practical waterworks experience and a knowledge of bacteriology and biology) for water examination and associated problems—The Engineer-in-Chief, South Staffordshire Waterworks Company, 50 Sheepcote Street, Birmingham 15.

ASSISTANT CHEMIST (with a university degree, or A.R.I.C., with analytical experience) for work on vacuum filtration and biological oxidation of sewage sludges; trade effluent control and routine control analysis—The Secretary, West Kent Main Sewerage Board, 20 Blyth Road, Bromley, Kent.

ASSISTANT or ASSOCIATE PROFESSOR OF GEOPHYSICS—Head of the Department of Physics, University of British Columbia, Vancouver, B.C., Canada.

GEOLOGIST (with a first-class or second-class (Division 1) degree in geology, and prepared to work under camping conditions) IN THE GEOLOGICAL SURVEY DEPARTMENT, Gold Coast Government—The Director of Recruitment (Overseas), Gold Coast Office, 13 Belgrave Square, London, S.W.1.

HEAD OF THE CHEMISTRY DEPARTMENT—The Headmaster, Maidstone Grammar School, Maidstone, Kent.

LECTURER (woman, with sound academic qualifications and teaching experience) IN MATHEMATICS—The Warden, Goldsmiths' College, New Cross, London, S.E.14.

NATIONAL RESEARCH COUNCIL OF CANADA POST-DOCTORAL FELLOWS IN THE DEPARTMENT OF CHEMISTRY—Principal H. G. Thode, McMaster University, Hamilton, Ontario, Canada.

PHYSICAL METALLURGIST (with an honours degree in metallurgy, and preferably some postgraduate training and industrial experience) for industrial research and development—The Director, British Columbia Research Council, University of British Columbia, Vancouver, B.C., Canada.

PILOT-BIOLOGIST (with a biological degree and the ability to pilot light aircraft), to assist in the study of the populations and ecology of wildfowl—The Assistant Director (Research), The Wildfowl Trust, Slimbridge, Gloucestershire.

READER IN POLYMER SCIENCE; a SENIOR LECTURER IN RUBBER TECHNOLOGY; a SENIOR LECTURER IN PLASTICS TECHNOLOGY; a LECTURER IN RUBBER TECHNOLOGY; and a LECTURER IN LATEX TECHNOLOGY—The Clerk to the Governors, National College of Rubber Technology, Holloway, London, N.7.

RESEARCH ASSISTANT (with a degree in chemical engineering or an allied subject, and preferably previous research experience either at a university or in industry) IN THE DEPARTMENT OF CHEMICAL ENGINEERING—The Registrar, University College, Singleton Park, Swansea.

RESEARCH FELLOW IN CERAMICS, for work on the structure and properties of glassy silicates in connexion with modern developments in vitreous enamels and glazes—The Zinc Development Association, 34 Berkeley Square, London, W.1.

SENIOR ANIMAL TECHNICIAN (with a diploma of the A.T.A.) to take charge of the animal house, under direction—The Administrative Officer, Medical Research Council Laboratories, Holly Hill, Hampstead, London, N.W.3.

SENIOR BIOLOGY MASTER—The Headmaster, Brighton College, Brighton 7.

SENIOR TECHNICIAN or TECHNICIAN (with experience in hospital biochemistry) IN THE DEPARTMENT OF CHEMICAL PATHOLOGY—The Secretary, Guy's Hospital Medical School, London Bridge, London, S.E.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Scientific Proceedings of the Royal Dublin Society. Vol. 27 (N.S.) No. 7 (24th August, 1956): The Gametophytes and Embryogeny of *Athrotaxis*. By M. Brennan, S.J., and J. Doyle. Pp. 193–252+*plates* 4–8. 20*s*. No. 8 (12th October, 1956): Escalops (*Pecten Maximus* L.) in Irish Waters. By F. A. Gibson. Pp. 253–272. 5*s*. No. 9 (15th October, 1956): Stokes' Law. Part 1: Conductivities of Organic Ions. By John T. Edward. *Pp. 273–288. 2s. 6d. (Dublin: Royal* Dublin Society, 1956.) [1412

University of Hull. Second Report of Council and Report of Senate for the Academic Year 1st October 1955 to 30th September 1956, and *Accounts for the year 1st August 1955 to 31st July 1956.* Pp. 61. (Hull: The University, 1956.) [1712

British Broadcasting Corporation: Engineering Division. Monograph No. 9: The Application of Phase-Coherent Detection and Correlation Methods to Room Acoustics. By C. L. S. Gilford and M. W. Greenway. Pp. 14. (London: British Broadcasting Corporation, 1956.) 5*s*. [1712

Aero Research Technical Notes. *Bulletin No. 166: "Araldite" in* the Woodworking Industry. Pp. 6. (Duxford: Aero Research Limited, 1956.) [1712

Southern Regional Council for Further Education. Ninth Annual Report, October 1956. Pp. 38. (Reading: Southern Regional Council for Further Education.) [1712

British Scientific Instrument Research Association. Research Report M.24: Determination of Moisture in Solids—a Short Survey of Methods and Apparatus. By P. J. Geary. Pp. iv+52. (Chislehurst: British Scientific Instrument Research Association, 1956.) 7*s*. 6*d*. Overseas purchasers, 9*s*. 6*d*. [1712

Other Countries

United States Department of the Interior: Geological Survey. Water-Supply Paper 1249: Surface Water Supply of Hawaii, 1951–52. Prepared under the direction of J. V. B. Wells. 40 cents. Water-Supply Paper 1260-D: Floods of 1952 in California. By S. E. Rantz and H. E. Stafford. Pp. vi+531–576+plate 6. 45 cents. Water-Supply Paper 1265: Water Levels and Artesian Pressures on Observation Wells in the United States, 1953. Part 1: Northeastern States. Prepared under the direction of A. N. Sayre. Pp. vii+337. 1.25 dollars. Water-Supply Paper 1266: Water Levels and Artesian Pressures in the United States, 1953. Part 2: Southeastern States. Prepared under the direction of A. N. Sayre. Pp. vii+275. 1 dollar. Water-Supply Paper 1317: Compilation of Records of Surface Waters of the United States through September 1950. Part 13: Snake River Basin. Prepared under the direction of J. V. B. Wells. Pp. v+566+1 plate. n.p. Water-Supply Paper 1321: Water Levels and Artesian Pressures in Observation Wells in the United States, 1954. Part 1: Northeastern States. Prepared under the direction of A. N. Sayre. Pp. vii+340. 1.25 dollars. Water-Supply Paper 1323: Water Levels and Artesian Pressures in Observation Wells in the United States, 1954. Part 3: North-Central States. Prepared under the direction of A. N. Sayre. Pp. vi+280. 75 cents. Water-Supply Paper 1324: Water Levels and Artesian Pressures in Observation Wells in the United States, 1954. Part 4: South-Central States. Prepared under the direction of A. N. Sayre. Pp. vi+230. 1 dollar. (Washington, D.C.: Government Printing Office, 1956.). [1412

United States Department of the Interior: Geological Survey Water-Supply Paper 1325: Water Levels and Artesian Pressures in Observation Wells in the United States, 1954. Part 5: Northwestern States. Prepared under the direction of A. N. Sayre. Pp. vi+167. 60 cents. Water Supply Paper 1334: Surface Water Supply of the United States, 1954. Part 2-B: South Atlantic Slope and Eastern Gulf of Mexico Basins, Ogeechee River to Pearl River. Prepared under the direction of J. V. B. Wells. Pp. x+386. 1.25 dollars. Water Supply Paper 1342: Surface Water Supply of the United States, 1954. Part 8: Western Gulf of Mexico Basins. Prepared under the direction of J. V. B. Wells. Pp. x+436. 1.50 dollars. Water-Supply Paper 1345: Surface Water Supply of the United States, 1954. Part 11: Pacific Slope Basins in California. Prepared under the direction of J. V. B. Wells. Pp. xii+574. 1.75 dollars. Water-Supply Paper 1363: Hydrology of Indiana Lakes. By. J. I. Perrey and D. M. Corbett. Pp. xi+347. 1.25 dollars. Water-Supply Paper 1365: Saline-Water Resources of Texas. By A. G. Winslow and L. R. Kister. Pp. v+105+9 plates. n.p. Water-Supply Paper 1368: Geology and Ground-Water Resources of the Upper Niobrara River Basin, Nebraska and Wyoming. By Edward Bradley. With a section on the Quality of the Ground Water. By F. H. Rainwater. Pp. iv+70+1 plate. 75 cents. Professional Paper 275: Geology and Mineral Resources of the Ivanpah Quadrangle, California and Nevada. By D. F. Hewett. Pp. vii+172+2 plates. n.p. Professional Paper 284: Geology and Ore Deposits of the Zimapán Mining District, State of Hidalso, Mexico. By Frank S. Simons and Eduardo Mapes V. Pp. vi+128+14 plates. n.p. Professional Paper 288: *Surficial Geology and Geomorphology of Potter* County, Pennsylvania. By Charles S. Denny. Pp. v+72+8 plates. n.p. (Washington, D.C.: Government Printing Office, 1956.) [1412

FAO Agricultural Development Paper No. 57: Pastures and Fodder *Crops in Rotations in Mediterranean Agriculture.* Prepared by P. A. Oram. Pp. viii+50. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1956.) 2*s*. 6*d*.; 50 cents. [1412

University of Travancore Research Institute. Zoological Memoirs. 1: Embryology of Heterometrus Scaber (Thorell). Arachnida: Scorpionidae. By A. P. Mathew. Pp. iii+96+14 plates. (Trivandrum: *University of Travancore Research Institute, 1956.)* [1412

Publications d l'Institut National pour l'Étude Agronomique du Congo Belge. Bulletin Climatologique Annuel du Congo Belge et du Ruanda-Urundi, Année 1955. (Bureau Climatologique—Communication No. 12.) Pp. 202. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1956.) [1412

New Zealand Forest Service. Annual Report of the Director of *Forestry, 1st April 1955 to 31 March 1956. Pp. 126. (Wellington:* Government Printer, 1956.) [1412

Proceedings of the California Academy of Sciences. Fourth Series. Vol. 28, No. 15 (November 19, 1956): Revision of the Nearctic Species *of Photinus (Lampyridae: Coleoptera).* By John Wagener Green. Pp. 561–613. (San Francisco, Calif.: California Academy of Sciences, 1956.) [1412

Annual Report of the Kodaikanal Observatory for year 1954. *Pp. 10. (Delhi:* Manager of Publications, 1955.) As. 9: 10*d*. [1412

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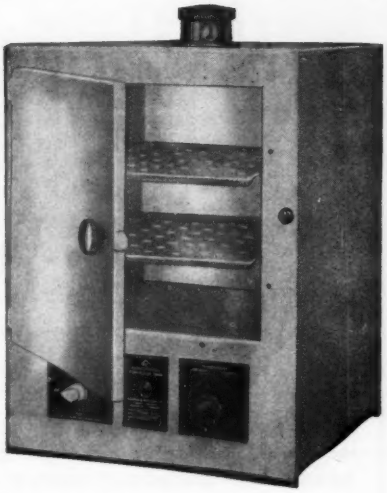

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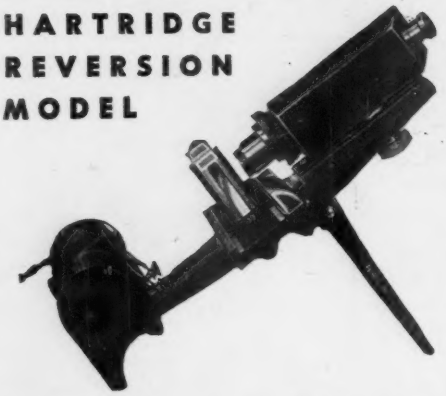

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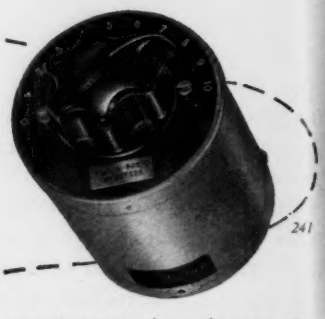

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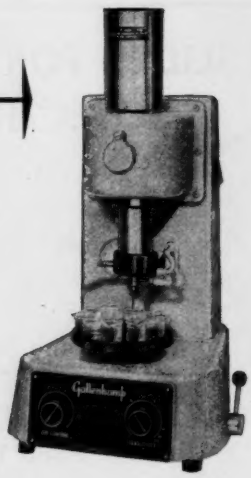

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